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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 78 MARCH, 1949 No. 1

A. D. E. ELMER: LEAFLETS OF PHILIPPINE BOTANY.

Adolf Daniel Edward Elmer, son of Jacob Van Dyne and Alvina Elmer, was born at Vandyne, Wisconsin, June 14, 1870. He married Miss Emma Osterman, of Arlington, Nebraska, who survives him, in 1902.

He was graduated from the Washington State College in 1899, and finished his work for the degree of Master of Arts at Stanford University in 1903. Later in the same year, he went to the Philippines, as collector of plants for the Bureau of Government Laboratories. This connection lasted only until 1905, when he began his long career as a private collector and student of Philippine plants.

The life of the private collector is at best a hard one. Its only probable personal reward is in serving the collector's personal interest. With training, skill, judgment, unremitting industry, and with luck, he makes a living. Elmer had the other qualifications, but at first no luck except his wife. He returned from his first field trip, and began the description of his collection and the preparation for distribution; and a flood, such as Americans had not yet learned to expect in Manila, inundated the city, and practically destroyed the entire collection.

Twice in later years, he had to come in for medical treatment, to return half-cured to finish his field work. Such experience weakens a man permanently, and after his Borneo trips he was never able to undertake any hard grind of field work.

On the other hand,—and this will perhaps give an idea of what thorough collection in the tropics involves,—on his Apo trip he was seven months without seeing a white man, and came out in good condition. But the Apo region is unique. It is paradise. In those days, the Bagobos could and would

explore the forest canopy, and do it with skill. A devoted botanist did not so much miss the amenities of white society when he could talk botany, and with the Bagobos he could do this with mutual satisfaction. As Elmer said, "Those Bagobos are good botanists." And if the force of this statement is not easy to grasp, let me testify that I have never known a botanist who could distinguish more local plants than could one old Bagobo, Angat. Elmer gave him Latin immortality, with *Solanum Angatii.* Naturally, this Apo collection was the most successful ever made by anybody in one season in the Philippines.

Elmer was primarily a botanist. He was a collector because collection served his kind of botany. Most collectors arrange with a staff of specialists to determine and describe their plants. Elmer did this with some specialists, but mostly his collections were material for his own study. To serve this purpose, he made field notes, the most uniformly good and ample I have known any collector to prepare. These notes were too ample for inclusion on herbarium labels, but were full of information which ought to be published.

To provide for the prompt publication of descriptions of his novelties, in one place and under his own control, Elmer decided to undertake the publication himself. Thus began his Leaflets of Philippine Botany. Among many such personal publications, this has been the outstanding success. At first, the printing was done by a local printer. As the collecting business was still paying an invisible profit for living expenses, he cheapened his publication by buying a little second-hand press, and became printer as well as collector, author and publisher.

At this point, his luck unsuspectedly reversed. Having a press, he did a job of job printing for a friend, who could not pay for it. To cancel the bad account, Elmer took in payment some valueless mining stock, and chucked it into a drawer to be forgotten. In later years, this stock paid in annual dividends many times its original cost; gave the Elmers a part of the measure of comfort in which they spent their later years; and gave their son, "our little Anton" when *Ilex Antonii* was named,—a Stanford education. Years later, another plant was named *Antonii,* this time for Dr. Anton D. Elmer.

The Leaflets ran their course, ten volumes, but with continuous pagination. In them, Elmer published descriptions of 1512 new species, besides a few new genera and varieties.

The number of articles was 137, mostly by Elmer, and mostly devoted wholly to the description of novelties. In a few papers, he treated families or genera, including all known Philippine representatives.

A number of articles were by specialists, reporting on Elmer's collections. Among the authors of such papers are Radlkofer, on Sapindaceae; Foxworthy, on dipterocarps; Ridley, on Zinziberaceae; Beccari, on palms; Martelli, on pandans; A. de Candolle, on Elaeocarpus; C. de Candolle, on Piperaceae; Kükenthal, on Carex; Ames, on orchids; Prain and Burkill, on yams; Christensen, on ferns; Stephani, on Hepaticae; Brotherus, on mosses; Hieronymus, on Selaginella; Zahlbrückner, on lichens; and H. and P. Sydow, Rehm, Murrill and Patouillard, on fungi.

Several papers are introduced by descriptions of the country where he collected, of the people, their life and industry, as well as, of course, the vegetation. These are entertaining and instructive reading, like Jagor's records of an earlier day, and ought not to be lost by the wider public because they are sifted into a very technical publication. Literary sparks occur elsewhere too; as where, in the desperate search for valid specific names in large genera with which we are all familiar. Elmer named a *Ficus* for his own ancestor, as *F. Adamsii* (corrected later to *F. Adami,* "named after the man who first recognized the utility of this genus."

Elmer worked under his own rules. His descriptions are all in English,—technically, not valid publication. As to type specimens, "holotypes," which the botanic world has come to respect during the years of Elmer's activity, he used to maintain that all specimens of one of his collection numbers were co-ordinate, that one specimen of a new species was as much a type as any other specimen. At the end, he fell into line, with the statement, p. 3831: "The type specimens of my new Philippine species of plants discovered and published in the *Leaflets of Philippine Botany* are preserved in my private type collection."

This type collection was kept, for safety, in the Philippine National Herbarium, in a "fire-proof" wing of the Bureau of Science. What may have endured bombardment was burned by the Japanese with the help of gasoline. The distributed isotypes are the nearest thing to types that now exist.

Immortality is conferred on collectors by giving their names to the novelties they collect. In such biographies as this, it

is common to conclude with a list of plants bearing the name of the subject. Of course, Elmer curtailed the list of plants bearing his name, by almost every paper he himself wrote. Of his fifteen hundred new species, at least a tenth would have been likely to bear his name if others had described them. Almost one-sixth of his novelties described by others do bear his name, but this proportion has to decrease with increase of numbers, because there can be only one *Ficus Elmeri,* one *Eugenia Elmeri,* one *Quercus Elmeri.* In spite of his describing the most of his new species, more than 120 have been given his name, a number so great that their listing ceases to magnify his honor. Genera are *Elmeria,* changed to *Adelmeria*; *Elmerina*; *Elmerinula*; and *Elmeriobryum.*

Elmer died of natural causes, in Manila, April 17, 1942, soon after the Japanese occupation, in time to escape the evil era of the concentration camps.

In spite of discouragement and difficulty, he had lived as he would. We may quote from him a fitting epitaph:

IT WAS ALL SO INTERESTING TO ME.

EDWIN B. COPELAND

PTERIDACEAE OF NEW GUINEA *

By EDWIN BINGHAM COPELAND
Of the University of California, Berkeley

SIX PLATES

Genus DICKSONIA L'Heritier

Key to the New Guinea species of Dicksonia

Major rachises black.
  Primary pinnules up to 16 by 4 cm..... 1. *D. grandis*
  Primary pinnules up to 10 by 2 cm..... 1a. *D. Ledermanni*
Major rachises dark brown.
  Hairs on rachises few or deciduous..... 2. *D. Schlechteri*
  Hairs comparatively persistent.
    Ultimate sterile teeth broadly triangular.
      Stout dark bristles mixed with fine reddish ones ..... 3. *D. Hieronymi*
      Hairs uniform ..... 3a. *D. sciurus*
    Sterile teeth narrow and sharp..... 4. *D. Archboldii*

1. DICKSONIA GRANDIS Ros.

D. grandis Ros., Fedde's Repert. *5* (1908) 34.

Mount Gelu, alt. 1,000 m, *Werner* 79, isotype in Herb. Univ. Calif.; *Brass 11897,* see comment under *D. Ledermanni.* Endemic.

1a. DICKSONIA LEDERMANNI Brause.

D. Ledermanni Brause, Engler's Jahrb. *56* (1920) 46.

Ledermann 8440, Hunstein Peak, alt. 1,050 m, type, not seen. *Carr 14769* is received as this species, and I accept the identification, because Mr. Alston visited Berlin while working on this collection. It is a tree fern, instead of an epiphyte as stated on the field label of the type; the pinnules are up to 10 cm instead of 7 cm long; and the rachises are black rather than dark-brown. Mr. Alston is in general likely to see resemblances where I am more impressed by differences, but I still accept this identification. However, I cannot dis-

* This paper includes the report on the ferns collected by the Third Archbold Expedition to New Guinea. Previous reports were published in the Philippine Journal of Science *73* (1940) 345–357; 457–469; *75* (1941) 347–361; *76* (1941) 23–25.

tinguish *Carr 14769* from the type collection of *D. grandis* by any probably specific difference. *Brass 11897* has the black axes of *D. grandis;* its frond, including the stipe, is 105 cm long, even smaller than *D. Ledermanni.* Except for having blacker axes and being more naked, it should be the latter species; except for stature, it is *D. grandis.* I believe it to be a depauperate form of *D. grandis,* and must then mistrust the distinctness of *D. Ledermanni.* As Brause mistrusted the field label of *Ledermann 8440,* so did I assume a misplaced label of *Brass 11897,*—"Rare low epiphyte in mossy forest;" but it is most extraordinary if this is a mistake made twice by good collectors or with well handled collections.

2. DICKSONIA SCHLECHTERI Brause

D. Schlechteri Brause, Engler's Jahrb. *49* (1912) 11.

Schlechter 17150, Kani Mountains, alt. 1,000 m, isotype in Herb. Univ. Calif; *Carr 15133,* Papua, alt. 8,500 feet. *Keysser II 8* (1912), Mount Bolan, alt. 2,400 to 3,000 m, is var. *glabrescens* Ros., Fedde's Report. *12* (1913) 165, isotype in Herb. Univ. Calif.; it may be a distinct species. Endemic.

3. DICKSONIA HIERONYMI Brause

D. Hieronymi Brause, Engler's Jahrb *56* (1920) 48; C. Chr., Brittonia *2* (1937) 282.

Ledermann 12851, Sepik region, alt. 1,400 to 1,500 m, not seen; *Brass 4550,* Murray Pass, Papua, alt. 2,840 m, det. C. Chr.; *Brass 9485, 10711,* Lake Habbema, alt. 3,225 and 2,800 m. Endemic.

3a. DICKSONIA SCIURUS C. Chr.

D. sciurus C. Chr., Brittonia *2* (1937) 283.

Brass 4991, Mount Tafa, alt. 2,400 m. I find on the isotype in Herb. N. Y. Bot. Garden a few stouter, longer and darker bristles among the otherwise smaller and brighter reddish ones. Endemic.

4. DICKSONIA ARCHBOLDII Copel. **Plate 1.**

D. Archboldii Copel., Univ. Calif. Publ. Bot. *18* (1942) 217.

Trunco teste Brassio 4 m alto sursum 13 mm crasso deorsum crassiore; foliis circa 10, 3.5 m longis, stipitibus 30–40 cm longis inclusis, lano basale fulvo-cinnamomeo denso crinito, stipite sursum rhachique setis fusco-cinnamomeis brevioribus (5–10 mm) obsitis, maximis sparsis delapsis tuber-

cula relinquentibus; pinna mediale 65 cm longa, 22 cm lata, subsessile, acuminata, subtripinnata, rhachi densissime setifera setis apicem versus pinnae parvis pallescentibus; pinnula primaria recte patente, brevi (1–2 mm)–pedicellata, acuminata, deorsum imbricante, basi 3 cm lata; pinnulis secundariis contiguis, brevipedicellatis, apice aciculati-mucronatis, circa 6 mm latis, aut omnino glabris aut costa inferne sparsissime setulosis; segmentis utroque latere usque ad 6, oblique positis, anguste decurrenti-connexis, inferioribus furcatis vel bis furcatis lobo acroscopico fertile, aliis acute dentiformibus; soris 1.5—2 mm latis, valvis stramineis integris vel irregulariter crenulatis.

Dutch New Guinea, 9 kilometers northeast of Lake Habbema, alt. 2,700 m, *Brass 10970,* "abundant in forest of lower slopes."

Characterized most clearly by the acute, dentiform, sterile ultimate segments. *D. sciurus* has some resemblance in this respect.

Genus CYSTODIUM J. Smith

CYSTODIUM SORBIFOLIUM (J. E. Smith) J. Smith

C. sorbifolium (J. E. Smith) J. Smith, in Hooker, Genera (1841) *Pl. 96.*

Dicksonia papuana F. v. M, Descr. Pap. Pl. IV (1876) 76.

King 230, 350, Brass 1084, 1470; Carr 12542, 12714, all from Papua at minor and moderate altitudes; *Schlechter 16519, 18463,* Kaiser-Wilhelmsland.

Moluccas; Celebes; Borneo.

Genus CULCITA Presl

CULCITA VILLOSA C. Chr.

Culcita villosa C. Chr., Brittonia *2* (1937) 283.

Brass 11589, Bele River, alt. probably 2,200 m. The type is *Brass 4791,* Vanapa Valley, Papua, alt. 1,900 m; isotype in Herb. N. Y. Bot. Garden.

Endemic. Related species from Australia and Polynesia to Malaya and the Philippines.

Genus ORTHIOPTERIS Copeland

Ithycaulon Copel., Univ. Calif. Publ. Bot. *16* (1929) 79.

The type species of *Orthiopteris* is *O. ferulacea* (Moore) Copel., Bishop Mus. Bull. *59* (1929) 14. That of *Ithycaulon* is

I. moluccanum Copel., since called *I. minus* (Hooker) C. Chr. The supposed essential difference was that *Orthiopteris* bore hairs, and in *Ithycaulon* the paleae, on the erect caudex. The near affinity, shown by the spores and otherwise, was noted in the publication of each genus. It has since appeared that *O. ferulacea* is really paleate. This is most obvious on *St. John 18311,* collected in 1937. The black-brown, thick, rigid paleae are rather more than 2 mm long, acute, lanceolate, forming a small apical tuft. This tuft is more or less concealed by the stipe bases of most collections, and the paleae are usually narrower. I find them narrower still, when present, on the bases of the stipes, where they suggest the bristles of *Dipteris.* With this correction as to *Orthiopteris, Ithycaulon,* described a few months later, became a synonym.

Key to New Guinea species of Orthiopteris.

Pinnules toothed, with undissected middle area.
- Undissected area over 3 mm wide.
  - Indusia narrowly cuneate at base..... 4. *O. minor*
  - Indusia broadly cuneate at base..... 5. *O. acuminata*
- Undissected area about 2 mm wide..... 3. *O. caudata*

Dissection complete, leaving no middle area.
- Segments and winged axes over 0.5 mm wide..... 2. *O. cicutarioides*
- Segments and winged axes under 0.4 mm wide..... 1. *O. trichophylla*

1. O. TRICHOPHYLLA Copel. **Plate 2.**

O. trichophylla Copel., Univ. Calif. Publ. Bot. *18* (1942) 218.

O. rhizomate suberecto, 1 cm crasso, paleis castaneis glabris integris ovatis 1–2.5 mm longis vestito; stipitibus fasciculatis usque ad 30 cm altis, fuscis, basi paleatis et squamulatis, sursum laminaque glabris; lamina usque ad 65 cm longa et 35 cm lata, acuminata, basi rotundata, herbacea, quinquepinnatifide dissecta, rhachillis tertiae ordinis et ultimis angustissime alatis, segmentis 1.5–3 mm longis, 0.2–0.3 mm latis, fertilibus ad gerendum soros tantum dilatatis; soris vix 1 mm longis, 0.5 mm latis, vix basi alatis.

Brass 12027, 15 kilometers southwest of Bernhard Camp, Idenburg River, alt. 1,800 m; "very abundant, tufted, terrestrial in rain forest."

More finely dissected than *O. ferulacea* and *O. cicutarioides;* the sori hardly winged; probably the most finely dissected fern of its size.

2. O. CICUTARIOIDES (Baker) Copel., comb. nov.

Davallia cicutarioides Baker, Journal of Bot. *28* (1890) 106.
Ithycaulon cicutarioides Alston, Journal of Bot. *77* (1939) 289.
I. tenuisectum C. Chr., Brittonia *2* (1937) 285.

Brass 12239, alt. 1,800 m; *Carr 13257,* Boridi, Papua, alt. 1,500 m; *Brass 3919,* Papua, alt. 700 m, isotype of *I. tenuisectum* in Herb. N. Y. Bot. Garden. I depend upon Alston for the interpretation of Baker's species. In describing *I. tenuisectum,* Christensen remarked on the resemblance to *O. ferulacea.* The latter is appreciably more finely divided, and thinner; and the sorus is in larger part unwinged, although this feature is not usually as conspicuous as it was figured by Hooker, Second Century of Ferns (1861) *Pl. 64.* Endemic.

3. O. CAUDATA Copel., comb. nov.

Saccoloma caudatum Copel., Philip. Jour. Sci. *30* (1926) 327.
Ithycaulon caudatum Copel., Univ. Calif. Publ. Bot. *16* (1929) 80.

Known only by the type, *King 462,* Hydrographers Range, alt. 900 m. Alston, [Journal of Bot. *77* (1939) 289] would reduce this to his *I. cicutarioides. Carr 13257,* by which I construe that species, has the tertiary pinnules more deeply and narrowly cut, although several times smaller.

4. O. MINOR (Hooker) Copel.

O. minor (Hooker) Copel., Genera (1947) 50.

Brass 12941, alt. 1,200 m; *12269,* alt. 1,700 m. approaching the next species; *Bamler, Rosenstock Fil. Novog. Exsicc. n. 116,* Wareo, alt. 600 m. To Malacca and Fiji.

5. O. ACUMINATA (Ros.) Copel., comb. nov.

Dennstaedtia acuminata Ros., Hedwigia *56* (1915) 350.
Ithycaulon acuminatum Copel., Univ. Calif. Publ. Bot. *12* (1931) 395.

Known by the type collection, *Bamler 139,* Sattelberg, alt. 800 m, isotype in Herb. Univ. Calif. As just noted, *Brass 12269* is very similar.

This fern is reduced by Alston, [Journal of Bot. *77* (1939) 289], to *Ithycaulon Novae-Guineae* (Ros.) Alston, which is *Oenotrichia Novae-Guineae* Copel. Alston remarks "I have the types of both Rosenstock's species." I have only isotypes, but have some reason to regard these as more authentic than the types, where there is any difference. Ours are the specimens retained by Dr. Rosenstock for his own use when he reputedly

sold the types. They fit the descriptions perfectly, which cannot be the case with Alston's types if the latter are congeneric. As to this *D.* (or *I,* or *O.*) *Novae-Guineae,* Rosenstock states: "Eine dem *Saccoloma moluccanum* (Bl.) Mett. gleichende Art, jedoch noch mehr zerteilt, und durch das Indusium wesentlich von ihm unterschieden. Dies ist breiter als lang und nach unten nicht verjüngt." It is certainly no *Ithycaulon,* no *Orthiopteris. O. acuminata* has the cuneate indusium base typical of the genus. Its distinctness from *O. minor* is questionable.

Genus DENNSTAEDTIA Bernhardi

Key to New Guinea species of Dennstaedtia

Pinnae and pinnules not articulate.
  Axes not aculeate.
    Veins setose on both surfaces.
      Herbaceous ..... 1. *D. penicillifera*
      Subcoriaceous ..... 2. *D. concinna*
    Veins setose beneath, naked above ..... 3. *D. magnifica*
    Veins naked on both surfaces.
      Rachises naked or glabrescent.
        Axes light-brown ..... 4. *D. cuneata*
        Axes dark ..... 5. *D. Shawii*
      Rachises pubescent ..... 6. *D. flaccida*
  Major axes aculeate.
    Frond tripinnatifid ..... 7. *D. resinifera*
    Frond at least quadripinnatifid.
      Lowest pinnules not dwarfed.
        Herbaceous ..... 8. *D. novoguineensis*
        Subcoriaceous.
          Ultimate segments acute ..... 9. *D. moluccana*
          Ultimate segments rounded ..... 10. *H. papuana*
      Lowest pinnules dwarfed ..... 11. *D. scandens*
Pinnae and pinnules articulate ..... 12. *D. glabrata*

1. D. PENICILLIFERA v. A. v. R.

D. penicillifera v.A.v.R., Bull. Jard. Buit. II No. *28* (1918) 17.
Hypolepis grandifrons Gepp, in Gibbs, Dutch N. W. New Guinea (1917) 195.

Described from Humboldt Bay, alt. 500 feet. With this plant, with limited confidence, I identify *King 244,* from Papua.

Mindanao, *Copeland 1755.* Both of these specimens have been confused with *D. samoensis* (Brack.) Moore, which has also been reported from New Guinea.

2. D. CONCINNA Ros.

D. concinna Ros., Hedwigia *56* (1915) 349.

Known by the original collection, *Bamler 1,* Sattelberg, isotype, in Herb. Univ. Calif. Its sori are those of *Microlepia* rather than of *Dennstaedtia,* and Rosenstock himself changed the generic name on our label. However, the affinity is with species recognized as *Dennstaedtia.*

3. D. MAGNIFICA Copel. **Plate 3.**

D. magnifica Copel., Univ. Calif. Publ. Bot. *18* (1942) 218.

Stipite teste Brassio 3.1 m, lamina 3.9 m longis; rhachi cinnamonea setis minutis sparsa; pinna visa (non infima) patente, sessile, 110 cm longa, rhachi (nisi in sulca) glabra straminea; pinnulis^{i} circa 18 cm longis, sessilibus, acuminatis, recte patentibus, vix contiguis; pinnulis^{ii} circa 3 cm longis, basi 1 cm latis, deinde ad apicem subacuminatum angustatis; pinnulis^{iii} circa 6 mm longis, supra basin cuneatam 3 mm latis, obtusis, oblique profunde incisis, firme papyraceis, costis inferne sparse setuliferis aliter glabris, superne atroviridibus inferne pallidioribus; soris in sinubus, deflexis, parvis (0.7 mm latis), indusii valva interiore paulo minore.

Dutch New Guinea, 6 kilometers southwest of Bernhard Camp, Idenburg River, alt. 1,050 m, *Brass 12982,* on bank of stream.

Distinguished from most of the related species by the acute to acuminate secondary pinnules.

4. D. CUNEATA (J. Smith: Hooker) Moore

D. cuneata (J. Smith: Hooker) Moore, Index (1857) XCVII.

Schlecter 16606, Kaiser-Wilhelmsland, alt. 200 m.
Philippines; Malaya.

5. D. SHAWII Copel.

D. Shawii Copel., Philip. Jour. Sci. *30* (1926) 326.

Known only by the type, *Rev. P. C. Shaw, King 491;* mountains behind Taupota.

6. D. FLACCIDA (Forster) Bernhard

D. flaccida (Forster) Bernhard, Schrader's Journal "1800" (1801) 124, *Pl. 1, f. 3.*

Reported from New Guinea; not known to me.

Pacific Islands. Although the type of the genus, this species is almost unknown.

7. D. RESINIFERA (Blume) Mett.

D. resinifera (Blume) Mett.: Kuhn, Ann. Lugd. Bat. *4* (1869) 290.

Listed by report; another mysterious species.
Java.

8. D. NOVOGUINEENSIS (Ros.) Copel., comb. nov.

Dennstaedtia Smithii var. *novoguineensis* Ros., Fedde's Repert. *10* (1912) 323.

Bamler S 49, Sattelberg, isotype in Herb. Univ. Calif.; *Clemens s. n.,* Morobe, alt. 4,200 feet. Differs from *D. Smithii* most essentially in having spiny axes. The two are probably not intimately related.

9. D. MOLUCCANA (Blume) Moore

D. moluccana (Blume) Moore, Index (1857) XCVII.

Brass 12267, alt. 1,800 m. *Keysser 18,* received with this name, is a distinct, probably undescribed, species.
Moluccas; farther range questionable.

10. HYPOLEPIS PAPUANA Bailey

Hypolepis papuana Bailey, Queensland Agric. Journal *23* (1909) 159.

King 440 is probably this species,—was so identified by Bailey,—but has a thing inner (extrorse) indusium, which I cannot detect on other sheets, apparently of the same species. The Bagobos long ago called my attention to the close affinity of *Hypolepis* and some species of *Dennstaedtia.* Endemic.

11. D. SCANDENS (Blume) Moore

D. scandens (Blume) Moore, Parker's Cat. (1858); Index (1861) 307.

Brass 11519 alt. 2,200 m; Bamler *s. n. Rosenstock Fil. Novog. Exsicc. n. 204,* Sattelberg, received as *D. moluccana. Schlechter 18945* probably belongs here, but our specimen is defective.
Malaya to Tahiti.

12. D. GLABRATA (Cesati) C. Chr.

D. glabrata (Cesati) C. Chr., Index (1905) 217; Dansk Bot. Arkiv. *9* No. 3 (1937) 42.
Dicksonia glabrata Cesati, Rend. Ac. Napoli *16* (1877) 28.
Dicksonia rhombifolia Baker, Journal of Bot. *28* (1890) 105.
Dicksonia erythrorachis Christ, Ann. Jard. Buit. *15* (1897) 86, *Pl. 13, f. 7.*
Dennstaedtia articulata Ros., Fedde's Repert. *10* (1912) 322.
D. Rosenstockii v.A.v.R., Bull. Jard. Buit. II No. 7 (1912) 11.

These synonyms apply to New Guinea specimens, and are taken from Christensen, l. c. (1937). If the species be thus broadly construed, I believe that it must include *D. ampla* (Baker) Bedd, also reported from New Guinea. My own belief is that several closely related species are here combined; but it is certain that more species have been described in this group than are justified by the number of collections.

Brass 13462, alt. 850 m. Many previous collections.

To Fiji and the Malay Peninsula, as here construed.

Genus MICROLEPIA Presl

Because the assignment of various species to one or the other genus is problematical, it would be better if all *Microlepia* species were transferred to *Dennstaedtia.* The discrimination of the species is also unsatisfactory. Curiously, neither the collection under study, nor the greatest previous one, Ledermann's includes any *Microlepia.*

Key to New Guinea Species of Microlepia

Bipinnate, most pinnules subentire ..... 1. *M. strigosa*
More compound.
  Rachis black ..... 2. *M. melanorhachis*
  Rachis stramineous to brown.
    Densely setulose, hairs with bulbous bases ..... 3. *M. trichosticha*
    Hairs without bulbous bases.
      Pinnules over 10 cm long, lanceolate ..... *Denn. concinna*
      Pinnules relatively broad, mostly shorter.
        Pinnules 10 by 5 mm, hardly incised ..... 4. *M. pseudohirta*
        Frond more finely dissected ..... 5. *M. Speluncae*

1. M. STRIGOSA (Thunb.) Presl

M. strigosa (Thunb.) Presl, Epim. (1849) 95.

A specimen collected by Mrs. Clemens, from Boana, Morobe, alt. 1,000 m, seems to be a small form of this species, reported from New Guinea, distinguished by small subentire or incised pinnules and long, whitish hairs.

To Japan.

2. M. MELANORHACHIS Ros.

M. melanorhachis Ros., Fedde's Repert. *12* (1913) 526.

Keysser 179, Sattelberg Hinterland, alt. 1,400—1,500 m, in Herb. Univ. Calif. Subquadripinnate, with small, cuneiform segments. Endemic.

3. M. TRICHOSTICHA J. Smith

M. trichosticha J. Smith, Journal of Bot. *3* (1841) 416, *nomen.*
Davallia trichosticha Hooker, Sp. Fil. I (1846) 183.

Cited from New Guinea as var. *glabrata* Prantl. As a Philippine species, this plant is well characterized by dense, short hairs with bulbous bases. *King 458,* Hydrographers Range, alt. 600 m, is like it in aspect but not in pubescence.

Dennstaedtia concinna Ros. bears sori which mostly fall short of the margin, and would therefore be looked for in *Microlepia.*

4. M. PSEUDOHIRTA Ros.

M. pseudohirta Ros., Fedde's Repert. *9* (1911) 425.

The type is *King 308.* We do not have Rosenstock's specimen, but this plant seems to be *No. 174* of my set. *Brass 5295,* Mafulu, Papua, alt. 1,250 m, identified by Christensen, is the same as *King 174.* We do have *Bamler 29,* distributed as *Rosenstock Fil. Novog. Exsicc. n. 90* as *M. scaberula,* but the name changed by Rosenstock on our label to *M. pseudohirta;* it does not fit the description, and is very unlike *King 174.* It is not *M. scaberula,* but may be responsible for the listing of *M. scaberula* as a New Guinea species. Its indusium is drawn upward (toward the margin) at the sides, and would justify its description as a new species.

Schlechter 17575 is also misnamed *M. scaberula;* it may be a large *M. pseudohirta.*

5. M. SPELUNCAE (L.) Moore

M. Speluncae (L.) Moore, Index (1857) XCIII.

This spcies, regarded as very variable in dissection and pubescence, is the dumping ground for all *Microlepia* not named otherwise. Several such specimens are in hand from New Guinea. Among them may be the *M. pilosula* listed by Brause.

All warm lands; in most places a "collective species."

Genus OENOTRICHIA Copeland

O. NOVAE-GUINEAE (Ros.) Copel.

O. novae-guineae (Ros.) Copel., Univ. Calif. Pub. Bot. *16* (1929) 82.
Davallia Novae-Guineae Ros., Fedde's Repert. *5* (1908) 36.

Known only by the type collection, *Warner 73,* Mount Gelu, alt. 1,700 m, isotype in Herb. Univ. Calif. See comment above, under *Orthiopteris acuminata.*

Genus LINDSAEA Dryander

Many *Lindsaea* species which are bipinnate in full development produce also fully fertile simply pinnate fronds. If the frond is bipinnate, the leaflets (pinnae) on the main axis, and on its branches (technically, pinnules) are alike. In the key below I call them all pinnae, and describe the technically bipinnate fronds as fronds with branched axes. The basiscopic margin of the pinna is almost always entire; statements as to margin or dissection apply therefore to the acroscopic side. This is the only genus of considerable size in which I recognize fewer species than Brause did nearly thirty years ago.

Key to New Guinea species of Lindsaea

Pinnae dimidiate.
- Veins free unless in the sorus.
  - Rachis of frond unbranched.
    - Rhizome elongate, fronds distant.
      - Stipe short, 5 to 20 mm long.
        - Pinnae not deeply incised.
          - Larger fronds fully 4 cm wide..... 1. *L. sessilis*
          - Fronds 2 cm wide..... 2. *L. Foersteri*
        - Pinnae dissected ..... 3. *L. hymenophylloides*
      - Stipe normally at least 5 cm long.
        - Pinnae deeply incised..... 4. *L. roemeriana*
        - Pinnae crenate or lobed.
          - Pinnae cartilaginous-bordered ..... 10. *L. marginata*
          - Pinnae not bordered.
            - Pinnae bifid, distal lobe broad..... 11. *L. blanda*
            - Lobes or crenations several.
              - Fronds over 2.5 cm wide..... 12. *L. rhombifoliolata*
              - Fronds not over 2 cm wide.
                - Pinnae about 5 mm wide..... 8. *L. adiantoides*
                - Pinnae about 3 mm wide..... 9. *L. gracilis*
    - Rhizome short.
      - Pinnae entire to shallowly incised.
        - Lowest pinnae crowded, much reduced. 13. *L. brevipes*
        - Lowest pinnae not crowded.
          - Stipes brown ..... 14. *L. concinna*
          - Stipes black ..... 15. *L. crassipes*
      - Pinnae dissected.
        - Sori widened across segment tips..... 5. *L. Bakeri*
        - Sori cup-shaped, narrow ..... 5a. *L. Schlechteri*
  - Rhachis branched.
    - Rhizome short.
      - Pinnae dissected ..... 6. *L. tenuifolia*
      - Pinnae lobed or incised.
        - Sorus marginal ..... 16. *L. tricrenata*
        - Sorus inframarginal ..... 17. *L. Kingii*

Rhizome elongate.
Pinnae dissected ..... 7. *L. Versteegii*
Pinnae entire to shallowly incised.
Coriaceous ..... 18. *L. rigida*
Herbaceous.
Sori several, submarginal ..... 19. *L. microstegia*
Sori few, marginal ..... 16. *L. tricrenata*
Veins more or less anastomosing.
Rachis unbranched.
Pinnae about 2 mm wide..... 20. *L. sinuato-crenata*
Pinnae over 4 mm wide.
Entire plant dark ..... 22. *L. obscura*
Plant not remarkably dark.
Pinnae cartilaginous-bordered..... 23. *L. Schultzei*
Cartilaginous border not evident.
Rhizome elongate.
Margin inciso-crenate ..... 24. *L. Werneri*
Margin lobed ..... 30. *L. stolonifera*
Rhizome short ..... 31. *L. decomposita*
Rachis branched.
Pinnae entire or nearly so.
Pinnae broadly rounded at apex..... 25. *L. azurea*
Pinnae narrowed to obtuse apex..... 26. *L. papuana*
Pinnae crenate or shallowly incised.
Basal branches of frond forked..... 27. *L. furcata*
Basal branches not forked.
Sori near ends of pinnae..... 28. *L. sepikensis*
Sori along upper and distal margins. 21. *L. decomposita*
Pinnae lobed half-way to costa..... 29. *L. davallioides*
Pinnae not dimidiate.
Frond mostly pinnate, pinnae narrow..... 31. *L. ensifolia*
Frond mostly bipinnate, pinnae broad..... 32 *L. heterophylla*

1. L. SESSILIS Copel.

L. sessilis Copel., Philip. Jour. Sci. *6* C (1911) 82.

Brass 8840, Hollandia, alt. 50 m; *King 244* (type) and *271* (juvenile), *Brass 1077, 5471, Carr 11992,* Papua; *Werner 70, Keysser, Rosenstock Fil. Novog. Exsicc. n. 215,* Kaiser-Wilhelmsland. Some of these have been determined also as *L. repens, L. macraeana, L. pectinata* and *L. Merrillii,* any of which except the last may be a preferable name, according to the fineness with which one elects to discriminate between species. *L. sessilis* is the common local species or form of the group or species ranging from Mauritius to Hawaii, of which the oldest specific name is *L. repens* (Bory) *Thwaites.*

Solomon Islands.

2. L. FOERSTERI Ros.

L. Foersteri Ros., Fedde's Repert. *12* (1913) 527.

Keysser 193, Sattelberg Hinterland, isotype in Herb. Univ. Calif. Like *L. sessilis* but much smaller; it is approached by *Brass 5471.*

3. L. HYMENOPHYLLOIDES Blume

L. hymenophylloides Blume, Enum. (1828) 218.

Listed by Brause; I have no New Guinea specimen.
Malaya; Philippines.

4. L. ROEMERIANA Ros.

L. roemeriana Ros., Nova Guinea *8* (1912) 719.

Von Roemer s. n., 731, 1137, 1088, Dutch New Guinea; Brause cites three collections by Ledermann. Not seen. We have construed *L. hymneophylloides* rather loosely in the Philippines, and some specimens could be referred to *L. roemeriana. L. Wollastonii* v.A.v.R. (*Odontosoria tenera* Ridley) must be something of this kind, but its description does not make sense.

5. L. BAKERI C. Chr.

L. Bakeri C. Chr., Suppl. III (1934) 121; Brittonia *2* (1937) 287.
Asplenium Bakeri C. Chr., Index (1905) 102.
Davallia lanceolata Baker, Kew Bull. (1899) 119.
Lindsaea trichophylla Copel., Philip. Jour. Sci. *6*C (1911) 83.
L. Ledermanni Brause, Engler's Jahrb. *56* (1920) 130.

This synonymi is by Christensen (1937).
Brass 13651, alt. 750 m; *Lam 825, 944,* alt. 80 to 150 m; *King 262* (*type of L. trichophylla*), *Brass 3819,* Papua. Endemic.

5a. L. SCHLECHTERI Brause

L. Schlechteri Brause, Engler's Jahrb. *49* (1912) 28, *f. 1 J.*

Schlechter 19395, Kaiser-Welhelmsland, alt. 250 m. Not seen; but, by description and figure, it seems to be a small *L. Bakeri.*

6. L. TENUIFOLIA Blume

L. tenuifolia Blume, Enum. (1828) 219.
Lindsaea blumeana (Hooker) Kuhn, Ann. Lugd. Bat. *4* (1869) 277.

Brass 13737 A, 13754, alt. 50 and 570 m; common.
Malaya and Philippines to Fiji.

After trying to distinguish *L. blumeana* from *L. tenuifolia,* and finally deciding that it is impossible, I awaken to the fact that *Davallia blumeana* Hooker could not be the name of a

distinct species, because it was originally published as a synonym.

7. L. VERSTEEGII (Christ) v.A.v.R.

L. Versteegii (Christ) v.A.v.R., Malayan Ferns Suppl. (1917) 206.
Odontosoria Versteegii Christ, Nova Guinea *8* (1909) 157.
L. Rosenstockii Brause, Engler's Jahrb. *56* (1920) 128.

L. Versteegii is typified by *Versteeg 1222.* Under *L. Rosenstockii,* Brause lists five collections by Ledermann. I have seen none of these, and cannot distinguish the two species by the descriptions.

8. L. ADIANTOIDES (Blume) Kuhn

L. adiantoides (Blume) Kuhn, Ann. Lugd. Bat. *4* (1869) 278.

Brass 13494, alt. 850 m, typical; *11869,* alt. 1,800 m, very small, possibly *L. gracilis; 10761,* alt. 2,750 m, with a discernible marginal strand; *King 479; Brass 5079, 5122, 8699,* alt. 2,400 m, Papua.

Described from the Moluccas, and of questionable ocurrence farther West; Fiji.

9. L. GRACILIS Blume

L. gracilis Blume, Enum. (1828) 217.

Two collections by Ledermann reported. I have not seen this species here unless *Brass 11869* be so identified; it fits the description approximately, but comparison with Java specimens makes me regard it as a small *L. adiantoides.* The two are nearly related, not identical.

Malaya; Mindanao.

10. L. MARGINATA Brause

L. marginata Brause, Engler's Jahrb. *56* (1920) 126.

Brass 12021, 12213, 13051, 14131, alt. 850 to 1,500 m; described from *Ledermann 12660 and 11384;* also var. *falcata,* Brause No. *12864;* none of these seen. Near *L. adiantoides,* but usually distinct.

Endemic.

11. L. BLANDA Mett.

L. blanda Mett.: Kuhn, Linnaea *36* (1869) 80.

Brass 11256, Bele River, alt. 2,200 m; *Schlechter 18699,* Bismarck Mountains, alt. 1,800 m.

Described from Java.

12. L. RHOMBIFOLIOLATA v. A. v. R.

L. rhombifoliolata v.A.v.R., Nova Guinea *14* (1924) 4.

Known only by the type collection, *Lam 1892 partim,* Doorman Mountain, alt. 1,450 m; not seen. It might be an unusually ample *L. adiantoides.*

13. L. BREVIPES Copel.

L. brevipes Copel., Philip. Jour. Sci. *6*C (1911) 83.

Brass 13652, alt. 750 m; *King 237* (type), *266, Brass 3817,* Papua.

Reported from Amboyna.

14. L. CONCINNA J. Smith

L. concinna J. Smith: Hooker, Sp. Fil. I (1846) 205, *Pl. 61 B.*

Schlechter 19900, Bamler, Rosenstock Fil. Novog. Exsicc. n. 109, Sattelberg., alt. 500 to 900 m.

Philippines; Borneo; Palau.

15. L. CRASSIPES Ros.

L. crassipes Ros., Fedde's Repert. *5* (1908) 36.

Brass 13203, alt. 860 m; *Werner 74,* isotype in Herb. Univ. Calif. *L. crassipes* is not very near to *L. concinna,* but may be a form of *L. cultrata. Clemens 6020* in Herb. Arnold Arb. is a mixture, the major part being intermediate between *L. cultrata* and *L. crassipes.* The former is as yet unknown in New Guinea, and may not safely be reported on this evidence.

Endemic if distinct.

16. L. TRICRENATA Baker

L. tricrenata Baker, Journal of Bot. *28* (1890) 106.

Known only by the original collection, by MacGregor, Mount Musgrave.

17. L. KINGII Copel.

L. Kingii Copel., Philip. Jour. Sci. *6*C (1911) 83.

Brass 8838, alt. 50 m; *8929,* Cyclops Mountains, alt. 575 m; *King 241* (type), *280,* Papua.

Endemic.

18. L. RIGIDA J. Smith

L. rigida J. Smith: Hooker, Sp. Fil. I (1846) 217, *Pl. 63 A.*
L. monosora Ros., Nova Guinea *8* (1912) 720, non Copel.
L. monocarpa Ros., in C. Chr., Suppl. I (1913) 49.

Brass 11761, 12473. L. rigida was previously reported from New Guinea,—four collections by Ledermann. *L. monosora*

was based on *v. Roemer 785, 1163,* not seen. With the material now in hand the supposed distinctions disappear, except that I have never seen anastomosing veins in *L. rigida.*

Malacca, Ponape.

19. L. MICROSTEGIA Copel.

L. microstegia Copel., Philip. Jour. Sci. *6*C (1911) 83.

Brass 12214, alt. 1,750 m; King *272,* type, Papua; *Schlechter 17133,* Kani Mountain Range, alt. 1,000 m, received as *L. repens; Bamler 126,* Sattelberg, received as *L. pectinata* var. *brevipinnula* Ros; *Lam 1327,* Doorman River, alt. 300 m, received as *L. pectinata.* The Brass and Bamler collections have the margin shallowly lobed, one sorus on each lobe. If any New Guinea species may be *L. repens* or *L. pectinata,* it is not this one, but *L. sessilis.*

Endemic.

20. L. SINUATO-CRENATA v.A.v.R.

L. sinuato-crenata v.A.v.R., Nova Guinea *14* (1924) 30.

Known only by the type, *Lam 1888,* Doorman Mountain, alt. 1,450 m; not seen.

21. L. DECOMPOSITA Willd.

L. decomposita Willd., Sp. Plant. V (1810) 425.

Brass 13204, 13415, 13416; very common. *King 381, 416* have smaller and crowded pinnae; they may represent the ill known *L. ambigua* Cesati.

India to the Marquesas.

22. L. OBSCURA Brause

L. obscura Brause, Engler's Jahrb. *56* (1920) 132.

Known only by the original collection, *Ledermann 8969,* Etapenberg, alt. 850 m; not seen.

23. L. SCHULTZEI Brause

L. Schultzei Brause, Engler's Jahrb. *49* (1912) 29.

Brass 11868, alt. 1,800 m, identification not positive. The type is *Schultze 304 g,* Sepik region; not seen.

Endemic.

A cartilaginous strand reinforces the basiscopic margin in many or most species of *Lindsaea.* It is not rare on the rachiscopic margin. Extended around all margins, it character-

izes *L. rigida, L. marginata* and *L. Schultzei;* but a faint border of this kind can sometimes be detected on other species.

24. L. WERNERI Ros.

L. Werneri Ros., Fedde's Repert. *5* (1908) 37.

Brass 13387, alt. 850 m; *Werner 5,* Mount Gelu, alt. 1,000 m, isotype in Herb. Univ. Calif., *Schlechter 18144,* Finisterre Mountains, alt. 950 m.

A Sumatra specimen, *Winkler 194,* may belong here.

25. L. AZUREA Christ.

L. azurea Christ, Verh. Nat. Ges. Basel *11* (1896) 429; Ann. Jard. Buit. *15* (1897) 101, *Pl 14, f. 12.*

Brass 13654, alt. 750 m, typical except for being larger; *Brass 3989,* Papua, alt. 50 m. The New Guinea plants should be var. *Mambae* v.A.v.R., Bull. Jard. Buit. *7* (1912) 21, the type of which is *King 48 p. p.*

Celebes.

26. L. PAPUANA Copel.

L. papuana Copel., Philip. Jour. Sci. *7*C (1912) 68.

Known only by the type, *King 358,* Lakekamu, Papua. As King sent this plant to me not long before he sent to Buitenzorg the plant named *L. azurea* var. *Mambae,* it may be suspected that they are the same. The brief varietal description of the latter might apply to *L. papuana.* The specimens cited above as *L. azurea* are not *L. papuana,* even though they approach it in size of pinnae.

Endemic.

27. L. FURCATA Copel. **Plate 4.**

L. furcata Copel., Univ. Calif. Publ. Bot. *18* (1942) 218.

Synaphlebium, rhizomate 2–3 mm crasso, brevi-repente, paleis minutis lanceolatis vestito; stipite 25–30 cm alto, brunneo, basi paleis paucis angustis 2 mm longis sparso, alibi nudo; lamina 30–35 cm longa, 25 cm lata, bipinnata, pinnis sessilibus, infimis typice angulo angusto furcatis, ramo basiscopico 15 cm, acroscopico 25 cm longis, pinnis sequentibus uni-jugis 20 cm longis, foliolo terminale fere 30 cm longo, pinnis omnibus valde acuminatis; pinnulis infimis flabelliformibus circa 7 mm longis, medialibus dimidiatis, 13 mm longis, basi cuneata 5 mm latis, brevissime stipitulatis, patentibus vel erecto-patentibus, apice

rotundatis, herbaceis, superne obscure viridibus margine acroscopico leviter crenatis lobis 4 ad 6 truncatis; venis laxe anastomosantibus; soris dilatatis, indusio cum margine conterminantibus.

Dutch New Guinea, 4 kilometers southwest of Bernhard Camp, Idenburg River, alt. 900 m, *Brass 13229*, "frequent low epiphyte in rain forest;" also *no. 13731, ibidem*, alt. 850 m, slightly smaller and with the basal pinnae not forked.

The frond form of the type is like that of *Pteris quadriaurita*, with single long basal prongs on the basal pinnae. I regard this as the normal frond of the fully mature plant, but it may possibly be only an abnormality. Without this peculiarity, the species seems to be distinguished by its few long, long-acuminate, ascending pinnae, many ascending pinnules, sparsely anastomosing veins, and marginal sori. In describing this species, I conform to usage and call the branches of the frond pinnae.

28. L. SEPIKENSIS Brause

L. sepikensis Brause, Engler's Jahrb. *56* (1920) 131.

Known only by the type, *Ledermann 9423*, Etappenberg, alt. 850 m; not seen.

29. L. DAVALLIOIDES Blume

L. davallioides Blume, Enum. (1828) 218.

Reported, and probably not uncommon, but we have no specimen from "continental" New Guinea. *Bamboer R 13* is from Rook Island, alt. 150 m.

Malaya; Philippines; Caroline Islands.

30. L. STOLONIFERA Mett.

L. stolonifera Mett.: Kuhn, Linnaea *36* (1869) 81.

Described from New Ireland, cited from the New Hebrides, and reported from New Guinea. Not seen.

31. L. ENSIFOLIA Swartz

L. ensifolia Swartz, Schrader's Journal "1800" (1801) 77.

King S 17, Brass 6027, Papua; *Bamler 143*, Sattelberg, alt. 100 to 200 m.

To Madagascar and Fiji.

32. L. HETEROPHYLLA Dry.

L. heterophylla Dry., Trans. Linn. Soc. *3* (1797) 41, *Pl. 8, f. 1.*

Reported here, but not seen.

To Madagascar and New Caledonia.

Genus TAPEINIDIUM (Presl) Christensen

Key to the species of Tapeinidium

Simply pinnate ..... 1. *T. longipinnulum*
At least bipinnate.
Indusium mostly wider than long..... 3. *T. obtusatum*
Indusium as long as wide..... 2. *T. moluccanum*
Indusium much longer than wide..... 4. *T. stenocarpum*

1. T. LONGIPINNULUM (Cesati) C. Chr.

T. longipinnulum (Cesati) C. Chr., Suppl. III (1934) 176.
Davallia longipinnula Cesati, Rend. Ac. Napoli *16* (1877) 29.
D. intramarginalis Cesati, *ibidem, teste* Christensen.
T. marginale Copel., Philip. Jour. Sci. *6*C (1911) 82.

Brass 8837, 13845, near sea-level; *King 283* (type of *T. marginale*), *349.*
Fiji.

2 T. MOLUCCANUM (Blume) C. Chr.

T. moluccanum (Blume) C. Chr., Gardens' Bull. *4* (1929) 399.
Davallia moluccana Blume, Enum. (1828) 237.
Davallia amboynensis Hooker, Sp. Fil. I (1846) 178, *Pl. 56 C.*

Brass 12102, 12958, 13363, alt. 850 to 2,100 m; *King 261; Schlechter, 18185.*
Moluccas.

3. T. OBTUSATUM v.A.v.R.

T. obtusatum v.A.v.R., Nova Guinea *14* (1924) 52.

Known only by the type, *Lam 1857,* Doorman Top, alt. 2,500 m; not seen. By description, this does not seem very distinct from *T. moluccanum.*

4. T. STENOCARPUM v.A.v.R.

T. stenocarpum v.A.v.R., Nova Guinea *14* (1924) 52.

Lam 1442, ridge near Idenburg River, alt. 1,420 m, isotype in Herb. Univ. Calif. Christensen, Suppl. III (1934) 176, reduces this to a variety of *T. moluccanum.* It seems to me to be sufficiently distinguished by its narrow, acute segments, as well as by its narrow indusia. As to its identity with *Davallia stenoloba* Baker, I have no opinion.

Brause lists also *T. Denhami,* which is *T. tenue* (Brack.) Copel., a Fiji species, and *T. pinnatum* (Cav.) C. Chr. As the latter is now construed more strictly than when he wrote, I do not know what his specimens would now be named.

Genus SPHENOMERIS Maxon

Key to New Guinea species of Sphenomeris

Larger segments and sori at least 4 mm wide..... 1. *S. retusa*
Segments about 2 mm wide..... 2. *Odontosoria decipiens*
Segments up to 1.5 mm wide..... 3. *S. chusana*

1. S. RETUSA (Cav.) Maxon

S. retusa (Cav.) Maxon, Journal Wash. Acad. Sci. *3* (1913) 144.

Brass 13279, alt. 850 m; *Bamler, Rosenstock Fil. Novog. Exsicc. n. 147.* Typical.

Philippines. Reported elsewhere.

2. ODONTOSORIA DECIPIENS (Cesati) Christ (?)

Odontosoria decipiens (Cesati) Christ (?)

King 170, Brass 1434, Papua; *Schlechter 16315. Lam 1352,* identified as this species, has much more narrowly cuneiform pinnules, like an enormously overgrown *S. chusana.* Christensen, Dansk Bot. Arkiv. *9* No. 3 (1937) 44, maintains, in agreement with Baker, that this is "a large and more compound form," of *S. retusa.* As he had seen the type, I may not dispute him; but the specimens cited here are not in my opinion *S. retusa.*

3. S. CHUSANA (L.) Copel.

S. chusana (L.) Copel., Bishop Mus. Bull. *59* (1929) 69.

Brass 10797, 11470, alt. 2,200 and 2,750 m; *King 184, Carr. 13957,* Papua.

Madagascar; India; Japan across Polynesia.

Genus ISOLOMA J. Smith

ISOLOMA FULIGINEUM Copel., comb. nov.

Schizoloma fuligineum Copel., Philip. Jour. Sci. *1* Suppl. (1906) 252, *Pl. 1 A.*
Nephrolepis Schizolomae v.A.v.R., Bull. Jard. Buit. *7* (1912) 22.
Schizoloma Schizolomae v.A.v.R., Malayan Ferns Suppl. (1917) 214.

Brass 8804, Hollandia, alt. 20 m.

Philippines; Borneo.

Christensen, Suppl. III (1934) 170, 171, reduces *S. fuligineum* to *S. ovatum,* to which I cannot assent; and makes *S. Schizolomae* a variety of *S. guirinianum,* which may be reasonable if one knows how to distinguish a variety from a species. The essential difference between them as species is that *I. fuligineum* has all or practically all veins free; I myself distrust this as a distinction.

Genus TAENITIS Willdenow

Key to New Guinea species of Taenitis

Hardly or not at all dimorphic ..... 1. *T. blechnoides*
Conspicuously dimorphic ..... 2. *T. requiniana*

1. T. BLECHNOIDES (Willd.) Swartz

T. blechnoides (Willd.) Swartz, Syn. Fil. (1906) 24, 220.

Brass 13293, 13617, alt. 750 to 900 m; *Bamler W 3,* Wareo, alt. 600 m; *King 153, Carr 12665,* Papua.

To Assam.

2. T. REQUINIANA (Gaud.) Copel.

T. requiniana (Gaud.) Copel., Univ. Calif. Publ. Bot. *16* (1929) 85.

Bamler, Rosenstock Fil. Novog. Exsicc. n. 252, Rook Island. Admiralty Ids.; Melanesia.

Genus SYNGRAMMA J. Smith

Key to New Guinea species of Syngramma

Frond pinnate ..... 1. *S. pinnata*
Frond simple ..... 2. *S. Hookeri*

1. S. PINNATA J. Smith

S. pinnata J. Smith, London Journal of Bot. *4* (1845) 168, *Pl. 7, 8, f. C.*

Brass 8999, Hollandia, alt. 100 m; *King 118, 298, Brass 5571, Carr 12663,* Papua.

Queensland; Fiji.

2. S. HOOKERI C. Chr.

S. Hookeri C. Chr. Index (1905) 346; (1906) 629.

Brass 12211, 13364, 13369, 13661, alt. 750 to 1,750 m; *King 355, 480, Brass 3804, 5231,* Papua.

Borneo; Fiji.

Genus CRASPEDODICTYUM Copeland

In establishing species in this genus, I have treated size, form, number and texture of leaflets, their insertion (stipitate or decurrent), the number of rows of areolæ, and the color of the stipe,—all as specific characteristics; and by these have thought to distinguish five species, to which Christensen has added a sixth. This may be correct; or, a considerable part of the supposed differences may be matters of variation within the species. Our collections are too few to afford a basis for confident judgment. Following my own precedent, I would now

describe one or two more species. However, with only seven New Guinea collections in hand; looking like five species, it is safer to deal tentatively with them, and let the future show which differences fluctuate and which are characteristic.

Key to New Guinea species of Craspedodictyum

Lateral leaflets decurrent ..... 1. *C. grande*
Lateral leaflets stalked ..... 2. *C. Schlechteri*

1. C. GRANDE Copel.

C. grande Copel., Philip. Jour. Sci. *6*C (1911) 84.

King 117, Ambasi, type of genus and species.
Solomon Islands.

This plant may be too near to *C. quinatum* (Hooker) Copel. I suppose that *Kajewski 508*, from Vanikoro, is topotypic and typical of that species. The lateral pinnae are decurrent, as described by Hooker; my key, Philip. Journal Sci. *38* (1929) 147, is incorrect; no New Guinea specimen matches *C. quinatum*.

2. C. SCHLECHTERI (Brause) Copel.

C. Schlechteri (Brause) Copel., Philip. Jour. Sci. *38* (1929) 147.

Syngramma Schechteri Brause, Engler's Jahrb. *49* (1912) 32.

Schlechter 18164, Finisterre Mountains, alt. 1,000 m, isotype in Herb. Univ. Calif. This plant is approximately matched by *Brass 8932*, Cyclops Mountains, alt. 450 m, and *13616*, Idenburg River, alt. 750 m; and by *Brass 1494*, Owen Stanley Range, Papua, alt. 1,200 m. To this species, if to either, must be referred *Brass 13662*, Idenburg River, alt. 750 m, and *King 268*,—these two probably identical; and two Bamler collections, *Rosenstock Fil. Novog. Exsicc. n. 114* and *114a*, presumably collected together and representing the local range of variation, but distributed with different names.

Genus LEPTOLEPIA Mettenius

L. NOVAE-ZELANDIAE (Col.) Kuhn

L. Novae-Zelandiae (Col.) Kuhn, Chaetopterides (1882) 348.

Zahn (1903) Yabim. With a single specimen, two fronds, I do not know whether or not the local plant is characterized by minor differences from those of Queensland (of which we have a single specimen) and New Zealand. However that is, if our data of origin are dependable, this is an interesting proof of geographic affinity.

Genus HYPOLEPIS Bernhardi

Key to New Guinea species of Hypolepis

Frond three to four times pinnate.
  Rachis smooth or rough, not muricate.
    Axes reddish.
      Axes hairy beneath ..... 1. *H. punctata*
      Axes more or less naked beneath..... 2. *H. bamleriana*
    Axes stramineous or buff.
      Sori abundant ..... 4. *H. tenuifolia*
      Sori few and one side of pinnules..... 4a. *H. grandifolia*
  Rachis spinescent ..... 5. *H. papuana*
Frond bipinnate ..... 3. *H. Archboldii*

1. H. PUNCTATA (Thunb.) Mett.

H. punctata (Thunb.) Mett.: Kuhn, Fil. Afric. (1868) 120.

Bamler, Rosenstock Fil. Novog. Exsicc. n. 173, quite like Formosa specimens; *Brass 10288, 10717,* near Lake Habbema, alt. 2,800 m, scrambling 3 m high, these representing var. *obscura* Brause, Engler's Jahrb. *56* (1920) 161, as does also *Brass 4970,* Mount Tafa, Papua. *Keysser II 7,* Bolan Mountains, alt. 2,400 to 3,800 m, received from Rosenstock as *H. bamleriana f. minor,* may be a small form of *H. punctata. Brass 4389,* Mount Albert Edward, is similar, but bears remarkably long reddish hairs beneath the costae.

New Zealand to Africa, Japan and Hawaii.

2. H. BAMLERIANA Ros.

H. bamleriana Ros., Fedde's Repert. *10* (1912) 325.

Bamler 39 (1908), Logaueng, alt. 300 m, isotype in Herb. Univ. Calif.

Endemic.

3. H. ARCHBOLDII Copel. Plate 5.

H. Archboldii Copel., Univ. Calif. Publ. Bot. *18* (1942) 218.

H. distanti Hooker affinis pilosa, rhizomate late repente, gracile, pilis aurantiacis vestito; stipitibus remotis, 15–20 cm altis, gracilibus, purpurascentibus, sparse pilosis; fronde 20–30 cm longa, 5–10 cm lata, acuminata, basi tripinnatifida, rhachi pilis fusco-aurantiacis crassis basibus bulbosis vestita; pinnis suboppositis, subsessilibus, inferioribus remotis brevioribus, medialibus usque ad 5 cm longis basi 15 mm latis, acutis, rhachibus deorsum angustissime sursum late alatis, pilis pallidioribus obsitis; pinnulis oblongis, obtusis, infimis pinnatifidis sequentibus lobatis, crenatis et integris, papyraceis, utraque facie sparse

setosis, decidue ciliatis; soris lobos et dentes fere complentibus, vix margine reflexo protectis vel omnino nudis.

Dutch New Guinea, 7 kilometers northeast of Wilhelmina Top, alt. 3,560 m, *Brause & Myer-Drees 9852,* common in ground moss in subalpine forest.

Similar to *H. distans,* and thus presenting another close link with the flora of New Zealand; and a member of the widespread group of *H. punctata. Brass 4235,* from Mount Albert Edward, alt. 3,690 m, determined by Christensen as a variety of *H. punctata,* is possibly *H. Archboldii,* but bears longer hairs, is more harsh, and not evidently ciliate. *Brass 4389,* referred to under *H. punctata,* is more distinct. Mrs. Clemens sends from Mt. Sarawaket, alt. 11,000 to 12,000 feet, a minute *Hypolepis,* the fronds 5 to 6 cm long, hardly bipinnate, and fruiting freely. It is probably *H. Archboldii,* and shows how far reduction can go.

4. H. TENUIFOLIA (Forster) Bernhardi

H. tenuifolia (Forster) Bernhardi, Schrade's Neues Journal *1* [2] (1806) 34.

King 168, Papua.

New Zealand to Japan.

4a. H. GRANDIFOLIA Gepp

H. grandifolia Gepp, in Gibbs, Dutch N. W. New Guinea (1917) 195.

Gibbs 6258, Humboldt Bay, alt. 150 m; not seen. "The huge fronds, the stipitate pinnules, and the few sori distinguish this species from the rest,"—but not very convincingly.

5. H. PAPUANA Bailey

H. papuana Bailey, Queensland Agric. Journal *23* (1909) 158.

Papua, the type collection, of which I have a fragment; also *King 465, Carr 12220, Brass 3956.* See comment under Dennstaedtia, species No. 10.

Endemic.

H. ACULEATA

H. aculeata Gepp, Journal of Bot. *61* (1923) Suppl. 59.

Forbes 555, Sogere, Papua, alt. 600 m. I have not seen this plant, and cannot by description distinguish it from *H. papuana.*

Genus PAESIA St. Hilaire

Key to New Guinea species of Paesia

Sterile segments over 1 mm wide, sori long..... 1. *P. radula*
Sterile segments under 1 mm wide, sori short..... 2. *P. lamiana*

1. P. RADULA (Baker) C. Chr.

P. radula (Baker) C. Chr., Index (1906) 476.

Brass 4603, 4709, Murray Pass, Papua, alt. 2,840 m, det. C. Chr.; *Keysser II 59,* Bolan, alt. 2,400 to 3,000 m. The latter is the collection responsible for the report of *P. scaberula,* Fedde's Repert. *12* (1913) 162.

Sumatra.

2. P. LAMIANA v.A.v.R.

P. lamiana v.A.v.R., Nova Guinea *14* (1924) 35.

Brass 12342, 12472, alt. 1,650 and 2,150 m. The type, not seen, is *Lam 1934,* Doorman Mountain, alt. 2,480 m. The Brass specimens are smaller than the type, and are accordingly at most quadripinnatifid, instead of quadripinnate or quinquepinnatifid. They seem well distinguished from *P. radula* by finer dissection.

Species of *Paesia* have been described from scanty material on the apparent assumption that they vary within narrow limits. I suspect that they are both variable and plastic, and that Rosenstock's identification of *Keysser II 59* is correct. In that case, *P. scaberula* ranges from New Zealand to Sumatra, and *P. radula* is a synonym. *P. lamiana* looks distinct, locally, but some New Zealand specimens are similarly dissected.

Genus PTERIDIUM Gleditsch

P. AQUILINUM (L.) Kuhn

P. aquilinum (L.) Kuhn, in v. Decken, Reisen *3*[3] Bot. (1879) 11.

Brass 11490, Bele River, alt. 2,200 m; *Carr 13228,* Boridi, Papua, alt. 1,300—1,400 m; these are substantially alike, and represent *Pteris lanigera* Blume.

Brass 8962, Hollandia, alt. 20 m, is less wooly than *No. 11490,* and may be *P. revolutum* (Blume) Nakai. We may have here two closely related species, altitudinally separate; or one species which responds with observable difference to the local environment; or the difference may be mere variation, appearing anywhere.

Genus HISTIOPTERIS (Agardh) J. Smith

Key to New Guinea species of Histiopteris

Stipule-like leaflets present ..... 1. *H. incisa*
Stipule-like leaflets wanting ..... 2. *H. estipulata*

1. H. INCISA (Thunb.) J. Smith

H. incisa (Thunb.) J. Smith, Hist. Fil. (1875) 295.

Brass 10750, alt. 2,800 m; *12320,* alt. 1,700 m; *Clemens 10165,* Mt. Sarawaket, alt. 3,300 m; *Carr 14385,* alt. 1,450 m, *King 229, 396,* Papua. Three species may be represented by these collections, but not even Brass' are sufficiently complete to provide a sure idea of the entire frond. His note on *No. 12320* shows a height of 3 m, and *No. 10750* looks like part of a still larger frond.

Pantropic, and to Japan and New Zealand.

2. H. ESTIPULATA v.A.v.R.

H. estipulata v.A.v.R., Nova Guinea *14* (1924) 25.

Brass 12040, 12438, alt. 1,750 and 1,800 m, epiphytic. The type is *Lam 1923,* Doorman Mountain, alt. 2,480 m, not seen.

Endemic.

Genus LEPIDOCAULON Copeland

L. CAUDATUM Copel.

L. caudatum Copel., Univ., Calif. Publ. Bot. *18* (1942) 218; Genera (1947) 60.

Rhizomate 3–5 mm crasso scandente, paleis castaneis lanceolato-ovatis 2 mm longis, decidue caudatis vestito; stipite 25 cm alto basi cum rhizomate continuo, paleis similibus basi aut cordatis aut sagittatis vestito, alibi nudo, atrocastaneo nitido; lamina 45 cm longa, 40 cm lata, deltoidea, basi tripinnata, pinnisque caudatis; pinnis suboppositis, infimis 22 cm longis basi 8 cm latis, basiscopice auctis acroscopice paulo angustatis; pinnula infima basiscopica 7 cm longa attenuato-caudata, pinnulis[ii] circa 6-paribus 1 cm longis 2 mm latis adnatis obtusis; pinnulis pinnarum superiorum remotis, anguste lanceolatis, acutis; costis inferne conspicuis pallidis, venis paucis inconspicuis, oblique marginem versus salientibus, deinde fertilibus margini parallelis.

Dutch New Guinea, 9 kilometers northeast of Lake Habbema, alt. 2,800 m, *Brass 10714;* "mossy forest of slopes; climbing on lower trunks of trees." Also, *No. 12051,* a single frond, Lake Habbema, alt. 3,225 m, an epiphyte in edge of forest; more ample than the type, and reflexed margin (false indusium) better developed. This reflexed margin is no more than suggested on the type.

The elongate rhizome with solenostele and the elongate submarginal sori or coenosori suggest affinity to such ferns as *Lind-*

saea ensifolia. The nearer affinity, shown best by the rhizome, is to *Histiopteris,* in spite of free veins and different pattern of frond. The paleae are true scales, not mixed nor intergrading with hairs. The stipe contains a single bundle, horse-shoe-shaped in section. A part of the long-caudate tips of the pinnae of the type are short-fastigiate at the very tip.

Genus PTERIS Linnaeus

Key to New Guinea species of Pteris

Veins free (except in sori).
- Pinnate with simple pinnae.
  - Stipe and rachis stramineous ..... 1. *P. vittata*
  - Stipe and rachis purplish ..... 2. *P. moluccana*
- Pinnate with lower pinnae forked.
  - Large fern with many pinnae ..... 3. *P. papuana*
  - Small or medium-sized, pinnae few.
    - Stipe smooth, usually stramineous.
      - Lamina herbaceous ..... 4. *P. cretica*
      - Lamina coriaceous ..... 5. *P. pellucida*
    - Stipe rough, dark ..... 6. *P. scabripes*
- Sparingly bipinnate.
  - Fronds uniform ..... 7. *P. deltoidea*
  - Fronds somewhat dimorphic ..... 8. *P. ensiformis*
- Pinnae pectinate or compound.
  - Pinnae pectinate on lower side only ..... 9. *P. semipinnata*
  - Pinnae pectinate on both sides.
    - Lowest pinnae not exceedingly enlarged.
      - Huge ferns.
        - Segments 1 cm wide above base ..... 10. *P. excelsa*
        - Segments much narrower ..... 11. *P. Gardneri*
      - Ferns of small or moderate size.
        - Apices of pinnae long caudate ..... 12. *P. ligulata*
        - Apices only moderately elongate.
          - Segments over 4 mm wide ..... 13. *P. blumeana*
          - Segments under 4 mm wide ..... 14. *P. pacifica*
    - Lowest pinnae greatly enlarged, fronds tripartite.
      - Ultimate divisions confluent segments.
        - Sori short, far from sinus ..... 16. *P. Schlechteri*
        - Sori long.
          - Large ferns.
            - Segments serrate at apex ..... 17. *P. Keysseri*
            - Segments entire ..... 18. *P. macrophylla*
          - Small, lamina about 20 cm long ..... 15. *P. Brassii*
      - Ultimate divisions free pinnules ..... 19. *P. montis-wilhelminæ*

Areolae single along costae ..... 20. *P. wallichiana*

Areolae in single rows along costules ..... 21. *P. tripartita*

Areolae numerous.
- Frond pinnatifid or pinnate ..... 22. *P. comans*
- Frond more compound ..... 23. *P. Warburgii*

1. P. VITTATA Linn.

P. vittata L., Sp. Plant. (1753) 1074.

Brass 11665, Balim River, alt. 1,600 m; apparently common at minor and midle altitudes.

Warm parts of the Orient, and adventitious elsewhere.

2. P. MOLUCCANA Blume

P. moluccana Blume, Enum. (1828) 208.

Several New Guinea collections at middle altitudes.

Moluccas; Solomon Islands (?)

3. P. PAPUANA Cesati

P. papuana Cesati, Rend. Ac. Napoli *16* (1877) 25, 29.

Brass 11314, alt. 2,200 m; *10886,* alt. 2,800 m; *Schlechter 16591,* alt. 1,500 m. *No. 11314* is the larger specimen, and has no forked pinnae. About half of those of *No. 10886* are forked or twice forked.

P. bambusoides Gepp, from the Arfak Mountains, described from a fragment, and *P. Brausei* Ros., *Taenitis Brausei,* Ros., Nova Guinea *8* (1912) 730, seem neither to be adequately distinguished from *P. papuana.*

Endemic; but not surely distinct from *P. opaca* of the Philippines.

4. P. CRETICA Linn.

P. cretica L., Mantissa (1767) 130.

A species or synspecies of world-wide distribution, reported in New Guinea, whence I have no specimen. The three following species are members of its group.

5. P. PELLUCIDA Presl

P. pellucida Presl, Rel. Haenk. I (1825) 55.

Brass 11508, Bele River, is this or an undescribed relative, still larger and with extravangantly caudate pinnae.

Philippines; Malaya.

6. P. SCABRIPES Wall.

P. scabripes Wall., List (1828) n. 94, *nomen;* Agardh, Rec. Sp. Gen. Pteridis (1839) 11.

A relative or form of *P. cretica,* listed here by report. Range doubtful.

7. P. DELTOIDEA Copel.

P. deltoidea Copel., Philip. Jour. Sci. *6*C (1911) 85.

Known only by the type, *King 242;* Papua.

8. P. ENSIFORMIS Burm.

P. ensiformis Burm., Fl. Ind. (1768) 230.

Common at minor altitudes.
Tropics of the Orient.

9. P. SEMIPINNATA Linn.

P. semipinnata L., Sp. Plant. (1753) 1076.

Listed here by report.
To Eastern India.

10. P. EXCELSA Gaud.

P. excelsa Gaud., in Freycinet, Voyage Bot. (1827) 388.

The New Guinea specimens I have seen with this name more probably represent *P. torricelliana* Christ, closely related but probably distinct.

A clear-cut Hawaiian species, apparently sporadic even into Asia.

11. P. GARDNERI (Fée) Hooker

P. Gardneri (Fée) Hooker, Sp. Fil. II (1858) 206.

Brass 11495, Bele River; *Bamler, Rosenstock Fil. Novog. Exsicc. n. 84,* alt. 300 m; *Carr 14431, 15435,* Papua. Large, like *P. torricelliana,* but with dark axes and much smaller and more numerous segments.

Philippines; Malaya to Tahiti.

12. P. LIGULATA Gaud.

P. ligulata Gaud., in Freycinet, Voyage Bot. (1827) 385.
P. beccariana C. Chr., Index (1906) 593.

Apparently common at minor altitudes, inconstant in form of frond.

Reported from the Solomon Islands to Borneo.

13. P. BLUMEANA Agardh

P. blumeana Agardh, Rec. Sp. Gen. Pteridis (1839) 22.

14. P. PACIFICA Hieron.

P. pacifica Hieron., Hedwigia *55* (1914) 355.

Both of these have been treated by most authors as forms of a pantropic species, *P. quadriaurita,* also reported from New Guinea,—*Bamler 45.* I have thought I could distinguish these two segregates elsewhere, but in New Guinea they seem to me indistinguishable.

15. P. BRASSII C. Chr.

P. Brassii C. Chr., Brittonia *2* (1937) 287.

Brass 5650, Mount Albert Edward, alt. 2,680 m. A small plant with deltoid fronds, related to the preceding species.

16. P. SCHLECHTERI Brause

P. Schlechteri Brause, Engler's Jahrb. *49* (1912) 33, *f. 2 B.*

Finisterre Mountains, alt. 1,200 m, *Schlechter 18190,* isotype in Herb. Univ. Calif.

Mindanao; Negros; Luzon (*P. quinquepartita* Copel.).

17. P. KEYSSERI Ros.

P. Keysseri Ros., Fedde's Repert. *12* (1913) 167.

Bolan Mountains, alt. 3,400 to 3,800 m, *Keysser II 10,* isotype in Herb. Univ. Calif.; Mt. Albert Edward, alt. 3,680 m, *Brass 4291.*

Endemic.

18. P. MACROPHYLLA Copel. Plate 6.

P. macrophylla Copel., Univ. Calif. Publ. Bot. *18* (1942) 218.

Rhizomate inviso; stipite teste Brassio 1.5–1.7 m alto, valido, brunneo vel stramineo, paleis aciculari-linearibus brunneis sparsis et nisi in sulcis deciduis ornato, sparse spinulifero; lamina tripartita, segmento (ramo) mediale 80 cm longo 30 cm lato bipinnatifido, pinnis basalibus oppositis 65 cm longis erecto-patentibus, pinnula infima basiscopica maxima et similiter furcata, rhachibus majoribus flabis spinuliferis; pinnis medialibus segmenti medialis usque ad 18 cm longis, 2 cm latis, sessilibus, caudatis, superne atroviridibus inferne brunneis, firme subcoriaceis, costis superne dentibus lanceolatis segmentis oppositis praeditis; segmentis proximis, adnato-confluentibus sinubus acutis, circa 12 mm longis, basi 4 mm latis, acutis, rectis vel subfalcatis; soris a basi fere ad apicem elongatis, indusio integro.

Dutch New Guinea, 9 kilometers northeast of Lake Habbema, alt. 2,700 m. *Brass 10298;* "forest undergrowth; occasional in wet bottoms."

Related to *P. Keysseri,* but larger, with smaller, closer and entire segments, and with spinulose axes.

19. P. MONTIS-WILHELMINAE Alston

P. montis-wilhelminae Alston, Journal of Bot. *78* (1940) 229.

Brass 9045, Lake Habbema, alt. 3,225 m, "frequent in moist open places in forest. Two or three rather fleshy large spread-

ing fronds on erect stipes 80–120 cm long;" *Brass & Myer-Drees 10056,* north slope of Mt. Wilhelmina, alt. 3,950 m, frequent among the stones of lime-stone screes. The type is *Versteeg 2532,* Mt. Wilhelmina, alt. 4,000 m, not seen. The podlike pinnules suggest those of *Onychium.*

Local.

20. P. WALLICHIANA Agardh

P. wallichiana Agardh, Rec. Sp. Gen. Pteridis (1839) 69.

Listed here by report.

India; Malaya; reported from Samoa.

21. P. TRIPARTITA Swartz

P. tripartita Swartz, Schrader's Journal "1800" (1801) 67.

Zahn, King, Carr; common at minor altitudes.

Old-World Tropics.

22. P. COMANS Forster

P. comans Forster, Prod. (1786) 79.

Reported but unknown to me in New Guinea.

Polynesia, very common.

23. P. WARBURGII Christ

P. Warburgii Christ, Monsunia I (1900) 70.

Brass 13459, alt. 850 m; apparently common throughout New Guinea. An isolated species, with broad lobes or pinnae and freely anastomosing veins, suggesting *Acrostichum.*

Moluccas.

Genus HEMIPTERIS Rosenstock

H. WERNERI Ros.

H. Werneri Ros., Fedde's Repert. *5* (1908) 38.

Werner 2, Gelu Station, alt. 1,000 m, isotype in Herb. Univ. Calif.; *Schlechter 10944,* Kani Gebirge, alt. 1,000 m.

Solomon Islands, *Brass 3329.*

Genus CONIOGRAMME Fée

C. MACROPHYLLA (Blume) Hieron.

C. macrophylla (Blume) Hieron, Hedwigia *57* (1916) 291.

Brass 12940, alt. 1,200 m; *Clemens* s. n., Morobe, alt. 1,400 m; this specimen is exactly like the Mindanao plant called *C. fraxinea* var. *Copelandi* by Christ, and transferred to *C. macrophylla* with the same varietal name by Hieronymus. *Carr*

15743 matches better the typical *C. macrophylla* of Java. Var. *undulata Hieron.*, Engler's Jahrb. *56* (1920) 160, was described from Schraderberg, alt. 2,070 m, *Ledermann 11813*.

Java; Mindanao.

Genus ACROSTICHUM Linnaeus

A. AUREUM L.

A. aureum L., Sp. Plant. (1753) 1069.

King 204, common along coast.

Pantropic in brackish swamps.

Genus CHEILANTHES Swartz

Key to New Guinea species of Cheilanthes

Herbaceous, stipe not scaly.	
Margin reflexed	1. *C. tenuifolia*
Margin flat	2. *C. javensis*
Coriaceous, stipe paleate.	
Frond 2.5–4 cm wide	3. *C. papuana*
Frond 5–10 cm wide	4. *C. belensis*

1. C. TENUIFOLIA (Burm.) Swartz

C. tenuifolia (Burn.) Swartz, Syn. Fil. (1806) 129, 332.

Brass 8960, Hollandia, alt. 20 m; *King 290*. I have also two collections purporting to be by Zahn, Sattelberg, alt. 900 m; one is this species; the other is more probably *C. Sieberi* Kunze, but I mistrust the data of collection.

New Zealand to India.

2. C. JAVENSIS (Willd.) Moore

C. javensis (Willd.) Moore, Index (1861) 244.
Notholaena hirsuta (Poiret) Desv., Journal de Bot. Appl. (1813) 93.

King 289, Papua.

Malaya; Philippines; Polynesia.

Notholaena distans R. Br., of New Zealand, Australia and New Caledonia, has been reported from New Guinea and from Celebes.

3. C. PAPUANA C. Chr.

C. papuana C. Chr., Dansk Bot. Arkiv *9* No. 3 (1937) 57.

Brass 9147, Lake Habbema, alt. 3,225 m; *Brass & Myer-Drees 9767, 9965, 10057, 10339*, Mt. Wilhelmina, alt. 3,500 to 3,960 m, det. C. A. Weatherby. The type is from Mt. Cars-

tenz, *1. Boden* Kloss, not seen. Doctor Weatherby's comment follows:

"*No. 10339* is rather strikingly different in appearance from the rest, with longer, more remote pinnae, but in all technical characters agrees with them.

"The excellent series obtained by Brass and Myer-Drees shows well the range of variation in the species and makes possible some additions to and emendations of Doctor Christensen's description. The rhizome is, as he inferred, ascending, short and about 5 mm in diameter, very densely covered with scales like those of the lower part of the stipe, and producing rather numerous, closely approximate fronds. The lower pinnae are not reduced; and the indusium, which is very narrow, scarcely 0.2 mm wide, is not intramarginal, as described. It may appear so when folded under the reflexed margin, but is actually a direct extension of the epidermis, apparently of the upper surface. The lower surface of the lamina in young fronds is densely beset with small, sessile, pale glands. The spores are densely short-echinate with conical, acute, rather thick processes.

"The collectors' notes describe the lower surface of the lamina in *Nos. 9147, 9965* and *10057* as "glaucous-white;" no such coloration appears in the dried specimens."

4. C. BELENSIS Weatherby

C. belensis Weatherby, Univ. Calif. Publ. Bot. *18* (1942) 218. *Pl. 7.*

Rhizoma breve circa 3 cm longum diametro 3 mm in specimine unico viso adscendens, paleis fusco-castaneis subrigidis concoloribus nitidis lineari-lanceolatis acuminatis integris e cellulis elongatis utrinque truncatis luminis coloratis vix translucentibus compositis dense onustum, apicem versus frondes plures laxe caespitosas emittens. Frondes (juveniles) and 3.6 dm altae, vetustiores verisimiliter majores. Stipes crassus teres castaneus opacus leviter albo-ceraceus quam lamina multo brevior, paleis brunneis ovatis acuminatis subtenuibus integris e cellulis brevibus irregularibus compositis plus minusve dense tectus. Lamina elliptico-lanceolata pinnato-pinnatifida vel bipinnato-pinnatifida ad apicem pinnatifidum acutum et ad basem angustata. Rachis stipiti similis paleas minores sparsioresque gerens. Pinnae ad 16-jugae (in frondibus juvenilibus solum perfectis visis) sessiles oblongae vel oblongo-lanceolatae obtusae latere basiscopico modice producto inaequilaterales profunde pinnatifidae vel pinnatae, pagina superiore glabrata venulis vix impressis, inferiore plus minusve albo-ceracea, costis costulisque prominentibus castaneis. Segmenta linearioblonga obtusa integra vel $\frac{1}{2}$ ad costam obtuse lobata, margine hyalino angustissimo continuo integro plus minusve glanduloso anguste revoluto instructa. Venae subremotae plerumque 2-furcatae, venulis sub angulo late acuto abeuntibus, apice cla-

vellato-incrassato juxta marginem soros gerentes. Sporangia in soris singulis pauca brevistipitata, annulo subangusto cellulis transverse angustis circa 20. Spori sphaeroidei brunnei diametro circa 35 μ rugis crassis subtortuosis processibusque late conicis acutis valde asperatis.

Dry, bare face of limestone cliff; one specimen only. 18 kilometers northeast of Lake Habbema, Bele River, alt. 2,200 m, November, 1938, *Brass 11210*, type in Herb. Arnold Arboretum, deposited at Gray Herbarium.

Cheilanthes belensis apparently has no near relatives except *C. papuana* C. Chr., with which it agrees in characters of scales and spores and its little developed "indusium." It differs in its oblong or oblong-lanceolate pinnae, the lower two or three pairs more or less reduced, in its ceraceous lower surface, the rachis and costae without capitate glands, and with far fewer and smaller scales, and in the non-impressed veins of the upper surface of the lamina. *C. farinacea,* which, at first sight, it resembles, has the scales of the rhizome and stipe with dark central band and pale margin, the lower pinnae not reduced, the hyaline margin strongly developed, and differently sculptured spores.

Genus PELLAEA Link

P. ZIPPELII (Miquel) Baker

P. Zippelii (Miquel) Baker, Synopsis (1874) 477.

Originally described from "Nova Guinea, in rupibus." Schlechter, Engler's Jahrb. *49* (1912) 5, lists this fern as a characteristic plant of bare slopes on the Finisterre Mountains.

Endemic, but closely related to *P. falcata,* and thus another witness of affinity to the flora of New Zealand.

Genus DORYOPTERIS J. Smith

Key to New Guinea species of Doryopteris

Frond trifid to axis or nearly so..... 1. *D. concolor*
Frond cut to a broad wing..... 2. *D. papuana*

1. D. CONOCOLOR (Langsd. and Fischer Kuhn

D. concolor (Langsd. & Fischer) Kuhn, in v. Decken, Reisen *3* 3 Bot. (1879) 19.

Reported and doubtless here, but I have no specimen. All warm lands.

2. D. PAPUANA Copel.

D. papuana Copel., Philip. Jour. Sci. *6*C (1911) 86.

King 208, type, Goodenough Bay; *388.*

Endemic. I cannot agree with Tryon in reducing this to *D. ludens.*

Genus ONYCHIUM Kaulfuss

O. SILICULOSUM Desv.

O. siliculosum Desv. C. Chr., Index (1905) 20; (1906) 469.

King 209, 333, Papua.

Malaya; Philippines.

Genus ADIANTUM Linnaeus

Key to New Guinea species of Adiantum

Frond simply pinnate.
- Glabrous ..... 1. *A. philippense*
- Hairy ..... 2. *A. caudatum*

Frond more compound.
- Hairy ..... 3. *A hispidulum*
- Glabrous (unless upper side of rachis).
  - Stipe at most 10 cm long ..... 4. *A. Kingii*
  - Stipe at least 15 cm long.
    - Sori orbicular ..... 5. *A. neo-guineense*
    - Sori wider than long.
      - Rachis hairy above ..... 6. *A. Christii*
      - Rachis naked ..... 7. *A. hollandiae*

1. A. PHILIPPENSE L.

A. philippense L., Sp. Plant. (1753) 1094.

Schlechter 16359, 16980, alt. 200 m; *Clemens* (host of a fungus), Morobe; *King 211,* Papua.

Africa to Polynesia; immigrant in tropical America.

2. A. CAUDATUM L.

A. caudatum L., Mantissa (1771) 308.

Carr 11747, Kanosia, Papua, sea-level.

West to India and Africa.

3. A. HISPIDULUM Swartz

A. hispidulum Swartz, Schrader's Journal "1800" (1801) 82.

Zahn, Yabim.

To New Zealand, India and Africa.

4. A. KINGII Copel.

A. Kingii Copel., Philip. Jour. Sci. *9*C (1914) 5.

Known only by the type, *King 420,* Tamata, Papua.

5. A NEO-GUINEENSE Moore

A. neo-guineense Moore, Gard. Chron. N. S. *7* (1877) 12.

Known only as from New Guinea, collected by Goldie.

6. A. CHRISTII Ros.

A. Christii Ros., Fedde's Repert. *12* (1913) 166.

Brass 10812, 12688. The type is *Keysser B 43,* Bolan alt. 2,400 to 3,000 m, isotype in Herb. Univ. Calif.

Endemic.

7. A. HOLLANDIAE v.A.v.R.

A. hollandiae v.A.v.R., Bull. Jard. Buit. *7* (1912) 1.

Known only by the type, *Giellerup 946,* Hollandia, not seen.

A. fulvum Raoul is also reported, on the cited evidence of *Ledermann 11761.* It is common farther East and South.

ILLUSTRATIONS

All are photographs of the types

PLATE 1. Dicksonia Archboldii Copel.
2. Orthiopteris trichophylla Copel.
3. Dennstaedtia magnifica Copel.
4. Lindsaea furcata Copel.
5. Hypolepis Archboldii Copel.
6. Pteris macrophylla Copel.

PLATE 1. DICKSONIA ARCHBOLDII COPEL.

PLATE 2. ORTHIOPTERIS TRICHOPHYLLA COPEL.

PLATE 3. DENNSTAEDTIA MAGNIFICA COPEL.

PLATE 4. LINDSAEA FURCATA COPEL.

PLATE 5. HYPOLEPSIS ARCHBOLDII COPEL.

PLATE 6. PTERIS MACROPHYLLA COPEL.

NOTES ON PHILIPPINE MOSQUITOES. XV THE CHÆTOTAXY OF THE PUPÆ AND LARVÆ OF TRIPTEROIDES [1]

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FOUR PLATES

This is an attempt to unify the widely differing terminologies used by various authors for the pupal setæ of mosquitoes, and to harmonize these terms with the popular numeral hair notations for the larva. It does seem quite surprising that while the pupal hairs are evidently the representatives of larval setæ, all the schemes heretofore employed for the pupal chætotaxy were conceived in complete disregard of correlation or homology with the larval hairs.[2] Such a correlation would seem naturally indicated when the pupal hairs become sufficiently visible during development inside the larval skin. In available literature and in practice among our own laboratory workers, one of the main criteria to determine a fourth instar larva is the appearance of the float hairs. At a certain stage these are readily seen through the larval cuticle on abdominal segment I. Among anophelines, the float hairs are directly or nearly directly underneath the palmate hair. These are similarly situated in culicines where the palmate hairs are represented by what is more commonly known as hair No. 1. By a careful examination of suitable specimens, the other pupal setæ on the abdomen could be seen more or less in the same precise location beneath the larval hair to which each corre-

[1] Submitted for publication, September 10, 1948.

[2] On October 30, 1948, when this was already in press, we received a copy of the latest work on pupal chætotaxy by K. L. Knight and R. W. Chamberlain entitled: A new nomenclature for the chætotaxy of the mosquito pupa, based on a comparative study of the genera. Proc. Helminth. Soc. Wash. 15 (1948) 1–10. It was not possible for us to reproduce one of their illustrations for comparison with what we show here, or to include their scheme in our discussions, but there are fundamental differences between their interpretation and numbering of hairs and ours. Only No. 5 of abdominal segments IV to VIII, and No. 13 of VIII are similarly designated. Their scheme, like others before it, is not based on homology or correlation with larval hairs. Of their many illustrations, No. 6 represents a pupa of *Tripteroides* (*Mimeteomyia*).

sponds. The profound changes in the form and contour of certain parts when the larva is transformed into pupa necessarily alter more or less decisively the positions and make-up of the hairs on these parts. The correlations of these particular hairs are, therefore, extremely difficult to determine. But in the main, the ones most valuable from the standpoint of classification are not so hard to correlate.

The most suitable specimens for the study of hair correlations are those where the pupal setæ are sufficiently visible through the larval skin. This is usually at the initial stage when the larva becomes pale and quiescent, indicating the changes that take place during pupation. Though advantageous for complete visibility of hairs, a pupa which has started to break through the larval skin or when about ready to do so is not suitable owing to alterations in position of its hairs. By a rapid examination of the living larva under a microscope, one can readily determine the suitable specimen. When found, it may be killed quickly but not too rapidly in warm water. Even in its death throes in warm water, a nearly mature pupa may wiggle out of its original position inside the larval skin. Suitable specimens may be mounted in balsam or any other medium containing no acetic acid. Acid clears the immature pupal hairs to complete invisibility.

The second half of this paper is likewise an attempt to homologize the hairs of a *Tripteroides* larva with those of an *Anopheles*. The schemes promulgated by different workers for the hairs on the head of culicines are different from those for anophelines, and are, moreover, not strictly based on homology. Some authors introduced hair notations for the thorax of culicines similar to the numeral hair designations for the thoracic hairs of anophelines, but none has been published to cover the abdominal chætotaxy of culicines. The varying patterns of hair arrangement on the head, and the great difference in morphology from that of anophelines, of abdominal segments VIII and IX render the homology of the hairs borne by these parts no easy matter to determine. The siphon, particularly, obliterates all signs of hair correlations.

In another part of these notes, we intend to include complete acknowledgments of what we owe different people concerning this study. For the present suffice it to mention those of the Department of Health under whom we worked directly, namely, Dr. Walfrido de Leon, Chief, Division of Laboratories; Dr. Antonio Ejercito, Chief, Malaria Control Section; and those of

the 19th MGL, U. S. Army, from the Commanding Officer, Col. D. M. Kuhns, to the last enlisted and civilian personnel of the Entomology Department, who offered to us the use of their specimens and laboratory facilities.

The pupal setæ.—Considerable reduction not only in total number but also in sizes of individual hairs takes place when the larva is transformed into pupa. The relative positions of certain hairs are also changed. Fusion of the (larval) head and thorax into the so-called (pupal) cephalothorax is accompanied by the elimination of many hairs and the alterations in positions of those that are left on these parts. In comparison, the abdominal hairs on I to VII suffer very little elimination though their sizes are generally very much reduced.

A total of nineteen pairs of hairs arise directly and indirectly from the head capsule of a *Tripteroides* larva; forty two from the thorax. But only three pairs of those on the head and nine of those on the thorax are represented in the pupal stage.

In spite of the difference in number of hairs between the larvæ of Group A and Group B,[3] subgenus *Tripteroides,* the number of pupal hairs is exactly the same for both groups. Normally each of the species with known pupæ of Philippine *Tripteroides* bears nine pairs of pupal hairs on abdominal segment I, eleven on II, while each of III to VII has twelve pairs. Quite often the only ventral hair on I and one of the two on II are absent; less frequently one of those on VII is also absent. Some species seem to have normally only one ventral pair even on II. If the socket which Baisas and others[4] think represents pupal hair 3 (of authors) is included, each of segments III to V will have thirteen pairs. Segment VIII bears only four pairs of hairs in either group.

In the larval stage Group B has more hairs on abdominal segments I to VII than Group A. This is due to the absence of hair 14 in all species of Group A. The larva of the local *Rachisoura* does not possess abdominal hairs 2 and 14. A more detailed discussion on larval hairs is given below.

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[3] Edwards, F. W. Genera Insectorum (932) Fasc. 194. 77–78.

[4] Baisas, F. E. Notes on Philippine mosquitoes, VII. Mon. Bull. Bureau of Health, *18* (1938) 182.

Stone A. and G. H. Penn. A new species of *Culex* from New Guinea Jour. Wash. Acad. Sci. *37* (1947) 90, *Fig. 7.*

A few hairs, in contrast, become more developed in the transformation to pupa. The most notable are the superior post-ocular hair (No. 3 of Rozeboom & Knight[5]), and the lateral tufts or the *A*'s of abdominal segments VII and VIII. The equivalents of these hairs in the larval stage, as we interpret them, are tiny. But the float hair (dendritic tuft of authors) which is very well developed and markedly exceeds the larval hair it represents in all anophelines and most culicines, is rudimentary in all species except one in Group A, and though developed in all of Group B is, nevertheless, hardly larger than the larval hair to which it corresponds.

Edwards[6] claims that rudimentary float hair is a general characteristic of treehole breeding mosquitoes. But this does not seem true for most of the Philippine treehole breeding species. Those of the local *Megarhinus, Orthopodomyia, Uranotænia,* and *Tripteroides* which breed in treeholes have very well developed float hairs. Even lesser amount of water in narrower spaces than ordinary treeholes does not seem detrimental to the development of the float hairs. The kind of *Aëdes* which breeds exclusively in leaf axils of *Colocasia;* the *Topomyia* found only in very tiny holes of "climbing bamboo"; the *Zeugnomyia* breeding in the leaf axils of *Livistona rotundifolia,* the *Tripteroides* known to breed only in pitcher plants; and that unusual *Tripteroides* which breeds in very little amount of water inside tiny forest shells—all of these have developed float hairs.

A few species, however, have rudimentary float hairs. The kind of Philippine *Ficalbia* found in treeholes in jungles, and all species, but one, of Group A, subgenus *Tripteroides,* which breed in pitcher plants have rudimentary float hairs.

Differences between the pupæ of Group A and Group B.— But for one partially annectant species, the pupæ of Group A can readily be separated from those of Group B by four well marked differences. The annectant form invalidates two of these. One is the character of the float hairs, and the other is the peculiarity of the respiratory trumpets. The float hairs are rudimentary, i. e., single or split into only two to about half a dozen branches, and the respiratory trumpets are relatively more stout with widely expanded but not deeply notched apices in Group A (except in the partially annectant species).

[5] Rozeboom, L. E. and K. L. Knight. The *Punctulatus* complex of *Anopheles.* Jour. Parasit. *32* (1946) 128, *Pl. IV.*

[6] Edwards, F. W. Mosquitoes of the Ethiopian Region, III (1941).

But in Group B the float hairs are dendritic and the respiratory trumpets are less stout and less expanded but deeply notched at the apices. The unusual species in Group A has well developed float hairs, and very much less stout respiratory trumpets the tips of which are, however, square cut and not notched. In common with all species of Group A, this partially annectant form has its superior postocular [7] hair comparatively much shorter, moderately stout, frayed, single, seldom branched, and the paddles do not have any visible midrib. The superior postocular hair in Group B is very long and prominent, not frayed, single in one species, split into two or three equal branches in all the others; while the paddle has very well defined midrib.

The hairs of the head.—When inside the larval skin, the postocular hairs are better seen from the ventral side. These are very close to the sites of hairs 13, 14 and 15 on the head of the larva. The inferior and median, or what Rozeboom and Knight designate as Nos. 1 and 2, are short and slender. They are usually not visible because they arise directly beneath the anterior portion of the dark imaginal eye. The superior, or No. 3 of Rozeboom and Knight, is very much longer specially in Group B, and being the only one of the three which is truly postocular in position, can readily be seen from the dorsal surface. The larval hairs 13, 14 and 15 are weak in all known Philippine *Tripteroides* and usually No. 14 is the weakest. By relative positions, the inferior corresponds to No. 13, the median to No. 15 and the superior to No. 14. No appreciable change in size of Nos. 13 and 15 takes place in pupation, but No. 14 becomes more stout and very much longer.

The thoracic hairs.—Though very much reduced in number, and generally also in sizes, the hairs on the three thoracic segments of the larva are represented in the chætotaxy of the pupa. The so-called antero-thoracic pupal hairs,[8] or Nos. 4 to 7 of Rozeboom and Knight, are apparently all that remain of the prothoracic larval hairs; the dorsal and supra-alar,

[7] The term "postocular" is by J. W. S. Macfie in:—The Chætotaxy of the Pupa of *Stegomyia fasciata.* Bull. Ent. Res. **10** (1920) 161–169. R. Crawford uses "ocular" in:—Some Anopheline Pupae of Malaya. (1938) 1–110.

[8] Knight, K. L. and R. W. Chamberlain consider the antero-thoracic pupal hairs part of the mesothoracic setæ, but as shown in our Plate 1, fig. 5, this is evidently not the case:—*Vide*—A new nomenclature for the chaætotaxy of the mosquito pupa, based on a comparative study of the genera. Proc. Helmint. Soc. Wash. **15** (1948) 1–10.

Nos. 9 and 10 of Rozeboom and Knight, are the remnants of the mesothoracic larval hairs; while the metanotal (*O, P* and *R* or 10, 11 and 12 of Rozeboom and Knight) are the representatives of the hairs on the metathorax of the larva.

The arrangement of the four antero-thoracic hairs in their original state is shown in Plate 1, fig. 5. The more internal two of these hairs are close to each other and farther from the other two which are also close together. The innermost is either directly underneath or a little anterior or posterior or somewhat internal or external to hair 1 on the prothorax of the larva. The other is similarly placed in relation to larval pro-hair 3. Pro-hair 2 of the larva seems eliminated.

Though also somewhat variable in position, the most external of these pupal hairs does not arise (in the *Tripteroides* specimens on hand) outer to the site of larval pro-hair 4. It may, however, be a little anterior or antero-internal or postero-internal to that hair. If this is taken as the equivalent of larval hair 4, the other would have to be considered the representative of either the larval pro-O or 2. No. 2 seems out of the question, while O is weak and not correlated in position to this hair. Our choice is to consider the outermost pupal hair as No. 5 and the other as No. 4, even if there is apparently as much reason to consider them No. 7 and No. 5 respectively since in all species of *Tripteroides* the larval prohairs 5 and 7 are developed. But the distance from the outermost pupal hair to the site of larval hair 7 is too wide to be in harmony with that which intervenes between the innermost pupal hair and the pro-hair 1 of the larva. It would seem reasonable to expect the two antero-thoracic pupal hairs to be external to larval pro-hair 4 if they were the equivalents of the larval pro-hairs 5 and 7. Moreover, the tendency of the cephalothoracic hairs to be more internally located than the larval hairs they represent is least on the region of the antero-thoracic, somewhat more where the dorsal and supra-alar hairs are located, and greatest on the metanotal.

When inside the larval skin or on mounted whole pupæ, the identity of the four antero-thoracic hairs, according to the nomenclature of Crawford or the numbers given by Rozeboom and Knight, is not readily evident. Furthermore, the upper of these hairs, as seen in quite a good series of mounted pupal skins of different *Tripteroides* on hand, sometimes seem to become the lower. Plate 1, fig. 5 shows our interpretation of these and other cephalothoracic hairs according to what seem their re-

spective equivalents in the larval hairs. We consider the innermost of the antero-thoracic or the "upper anterior" of Crawford or No. 6 of Rozeboom and Knight, as No. 1; the next or the "lower anterior" (of C.) or No. 4 (of R. & K.) as No. 3; the third or the "upper posterior" (of Crawford) or No. 5 (of Rozeboom and Knight) as No. 4; and the fourth or outermost or the "lower posterior" (of C.) or No. 7 (of R. & K.) as No. 5.

The dorsal hair (No. 8) and the supra-alar (No. 9) apparently represent the mesothoracic larval hairs 1 and 5 respectively. In Group A, No. 8 arises at the same level (underneath) but a little internal to the mesothoracic hair 1 of the larva, and the two are nearly equal in rank in most species. In Group B this hair is either directly beneath the base of, or a little anterior or posterior to, the large stellate tuft (No. 1) on the mesothorax of the larva; No. 9 is less obvious in homology, it being seemingly equal, in different species, to either 2 or 3 or 4 of the mesothoracic larval hairs. But as No. 5 is one of the most developed mesothoracic setæ, we prefer to regard the supra-alar as the remains of this hair.

The metanotal hairs (*O, P* and *R* of authors, or Nos. 10, 11, and 12 of Rozeboom and Knight) seem to represent respectively 1, 2 and 5 of the metathoracic larval hairs. The metanotal hairs do not differ significantly between the two groups of *Tripteroides,* but in the larval stage at least No. 1 is a large stellate tuft in Group B; much smaller, often single, in Group A. No. 12 is the one directly or nearly directly beneath larval hair No. 1; Nos. 10 and 11 being internal to it and not immediately near the site of any larval hair. This appears to be due to the contraction of the metanotum (metathorax) when transformed into pupa.

The abdominal hairs.—Because there is a maximum of only twelve pairs of hairs (thirteen if the socket on III to V is included) on an abdominal segment of a *Tripteroides* pupa regardless of the difference in number of hairs between Group A and Group B in the larval stage, it seems reasonable to assume that the hairs carried over to the pupal stage are identical in all species. Likewise (and logically it seems) the hairs not found on the larva cannot presumably be expected to appear on the pupa specially because the tendency in pupation seems to be the reduction of hairs. But this does not seem to be always the case. Hair 2 which is absent from the larva of one species, is still represented on the pupa of even this species; and though tiny, is not less so than those in

which this hair is well developed in the larval stage. On the other hand, No. 14 which is developed in Group B, but absent in Group A, is not represented on any of the known pupæ of Philippine *Tripteroides.*

The remarkable similarities in number and general arrangement of the pupal setæ in different genera and subgenera of mosquitoes is contrasted more or less markedly by the differences in their respective larval chætotaxy. This would seem to indicate that development and retrogression of hairs are first manifested in the larval stage, such that "new" larval hairs may not be expected to appear in the pupal stage, just as "old" ones which have already been eliminated from the larva may still be represented in the pupal stage. Abdominal hair No. 2 may be taken as an "old" hair which has been eliminated from the larva of one species but still exists on the pupa of even this species. Apparently this hair is being discarded from the larva of Group A since it is very tiny when present, and often absent from some segments or from all segments of some individuals in any species. In contrast, this hair is well developed and stellate in the larva of Group B, but also very tiny like that in Group A in the pupal stage. For a "new" hair, No. 14 seems this kind. It is well developed and stellate in the larva of Group B, but absent in Group A, and not represented in the pupal setæ of any species.

The general likeness in arrangement of pupal hairs displayed by different mosquitoes does not strictly mean homology between similarly placed hairs. This is because some hairs vary in positions not only in different species, but also on different segments of an individual, and sometimes also on different individuals of the same species. Similarities between two or more hairs, and their close proximity to each other on any part or segment increase the difficulty of recognizing these hairs. Moreover, when the pupa emerges from the larval skin and stretches out to assume its normal form, the relative positions of some hairs (indicated when yet inside the larval skin) are altered. Abdominal hairs 3, 4, 6, and 8 are specially affected by this stretching. Only by comparing the setæ of a free pupa or pupal skin with those of an immature pupa inside the larval skin of the same species can these hairs be properly identified.

Hair *B,* or what we designate as No. 5, is one of the most variable in position in different species and on different segments. Normally, in most species this is posterior and in-

ternal to Nos. 3 and 4 (of our scheme) on abdominal segments and IV. But it is often external to 3 and posterior to 4 on V to VII; or Nos. 3, 4 and 5 may be evenly aligned one after another. In certain species, No. 5 is normally internal to 4.

The arrangement of hairs on VII among individuals of any species in Group A is very variable. No. 5 (or *B*) of this segment is often so close to No. 6 (or *A*) it may be mistaken as (our) No. 8; or it may be rather far away and well internal to 4. Sometimes it is weaker than either 3 or 4. In mounted flat preparations, Nos. 8 and 12 (of our scheme) on this segment may appear either dorsal or ventral; while No. 8 is sometimes unusually close to 6.

Two or three species in Group A have all the abdominal hairs weak. Even *B* and *C* or Nos. 5 and 1 of these species cannot be easily picked out unless correlated with the positions of the larval hairs.

Quite often in routine examination, one runs across larvæ which are ready to molt to the fourth instar. In this stadium, each of the fourth instar larval hairs is beautifully placed directly underneath the corresponding hair on the enveloping third instar larval skin. There can be no question about hair equivalents in this. But the picture is not as clearly carried over to the stage when the fourth instar larva is about to shed its skin and give rise to an entirely different form, the pupa. Every part of the larva undergoes changes in pupation, and the number and arrangement of hairs are as much affected as the degree of change that takes place in the part where such hairs are located. It seems the fourth abdominal segment suffers the least change in form, and the hairs it bears are the least altered in arrangement. From segment IV the changes increase progressively either anteriorly or posteriorly, the greatest being at segment I, thorax, and head, and at the terminal segments of the abdomen. We use segment IV, therefore, as the basis of interpreting hair relationships, but at the same time we give due value to relationships which are better indicated elsewhere. Correlations between the lateral hairs, for example, are better shown on VI and VII (see Plate 1, figs. 1 and 2).

In parts or segments where changes due to pupation are great, homology of pupal hairs cannot be strictly based on proximity to certain larval hairs. For instance, on segment VII as shown in Plate 1, fig. 6, the pupal hair that corresponds to

larval hair 5 is directly underneath larval hair 4, while that which represents larval hair 4 is directly under larval hair 3. The true relationships of these hairs can be correctly understood only from hair correlations indicated on the middle segments.

Among the few *Anopheles* and *Culex* pupæ we examined, the large pupal hairs *B* and *C* on the abdomen are readily recognized since they are, on most segments, directly beneath larval hairs 5 and 1 respectively. In *Tripteroides,* however, *B* is more or less ventral with respect to larval hair 5, and *C* directly or almost directly under larval hair 1.

On the ventral side the relationship between pupal and larval hairs is less apparent. If judged only by its position on IV, pupal hair 8 (of authors) would seem to correspond to larval hair No. 11. But hair 8 is evidently identical with the only ventral hair (often absent) on I, which in turn appears to represent hair 13 of the larva. This varies in position on different segments and is unrecognizable when all the ventral setæ are of about the same sizes or types. The other ventral hairs, *D,* 6 and 7 (of authors) seem to be the equivalents of larval hairs 9, 12 and 7 respectively. *D* or 9 is usually the longest; 7 ranks next and may equal or even exceed 9 on the more posterior segments; while 12 is about equal to 13. As No. 12 becomes dorsal in position on V–VII in Group A, only three pairs are on the ventral surface of each of these segments except on VII in cases or individuals where what we propose to be designated No. 8 becomes ventral, or where No. 8 is dorsal, but 12 is on the ventral side. Mounted flat preparations are often confusing since some of the dorsal and ventral hairs come to equally clear definition under the same focus either under high or low magnifications.

The pair of tiny ventral hairs (No. 9 of authors) found in all *Anopheles* and most culicines is absent in *Tripteroides.* The pair on VIII of *Tripteroides* being similar to 9 on VIII of other culicines may be mistaken for this hair. But what *Tripteroides* possesses, as such, seems more reasonably the equivalent of No. 8 (of authors) on the preceding segments, or what we consider No. 13. Hair 13 is present also on VIII of the larva among *Tripteroides,* although this is laterally located in Group B; ventral, as usual, in Group A.

The chætotaxy of segments I and II differs somewhat from that of III–VII. *H* and the float hairs, just like *C′* and *C* of II–VII arise directly underneath or closely underneath

larval hairs 0 and 1 respectively, and so the float hair should be designated No. 1, and *H*, No. 0. *K, L, M, S, T,* and *U* are not immediately near the location of larval hairs. *K* in most species in Group B is the most prominent seta outside of the float hair, but it is comparatively much weaker in species of Group A. It seems the equivalent of what we regard as hair 2 (or 5 of authors) on the following segments. This may appear questionable, first, because hair 2 is not present on segment I of the larvæ among *Tripteroides,* and, second, it greatly outranks 2 of the other segments. Perhaps this is a vestige of an ancestral form which had hair 2 on I as in anophelines, while its size is understandable in the light of unusual variations in sizes of hairs. The *lh* on I and II in all kinds of mosquito larvæ are a good deal larger than those of other segments, yet in the pupal stage these are very much reduced on I and II and well-developed on VII and VIII. *L, M, S, T,* and *U* seem to represent larval hairs 3, 4, 5, 7 and 6, respectively.

In the nomenclature of authors for anophelines, segment II of the pupa is credited with two pairs of No. 1 and two pairs of No. 2 hairs. Even when in its original position inside the larval skin, the homology of the two No. 1 pupal hairs with the larval setæ is not evident because they are situated and pressed close to pupal hair *A* (of authors) on the lateral side of the segment. When released from the larval covering, they become farther apart. It seems that the first or the more external corresponds to the long secondary lateral hair or No. 7 of the larva, while the other corresponds to another lateral larval hair, No. 8. The more posterior, but often the more internal of the two No. 2 pupal hairs arises closely beneath larval hair No. 4, and the other closely beneath larval hair No. 3. *B* on this segment is rather far from larval hair No. 5, so its homology is based on evidences manifested on other segments. *C* and *C′* of segment II, like those of the succeeding segments, arise directly under or closely beneath larval hairs 1 and 0, respectively.

There is usually one pair of ventral hair on I and two on II. However, that on I and one of the two on II are absent from some individuals of species in which these hairs are normally present. Some species evidently have normally only one pair even on II. The ventral hairs are variable in position according to species and somewhat variable also among individuals within a species. That on I appears to be the equivalent of

larval hair 13. When only one pair is on the ventral side of II it seems to be also No. 13; and when there are two ventral pairs, the more external and anterior in position appears to be the equivalent of larval hair 12; No. 13, the inner and more posterior.

As a summary, and to harmonize the pupal hair notations with those of the larva, the following changes are proposed:

The post-ocular hairs.

The inferior (of Macfie), or No. 1 (of Rozeboom and Knight), should be No. 13 to correspond to sub-basal or post-mandibular hair or No. 13 of the larva.

The median, or No. 2 should be No. 15 to correspond to the infra-orbital hair, or No. 15, of the larva.

The superior, or No. 3, should be No. 14 to correspond to the orbital hair, or No. 14, of the larva.

The antero-thoracic hairs.

The upper-anterior, or No. 6, should be pro-1 to correspond to prothoracic larval hair No. 1.

The lower-anterior (of authors), or No. 4 (of Rozeboom and Knight), should be pro-3 to correspond to prothoracic hair 3 of the larva.

The upper-posterior, or 5, (sometimes this is the lower) should be pro-4 to correspond to prothoracic larval hair No. 4.

The lower-posterior, or 7 (sometimes this is the upper) should be pro-5 to correspond to larval hair No. 5 of the prothorax.

The dorsal hair, or No. 8, should be meso-1 to correspond to hair No. 1 on the mesothorax of the larva.

The supra-alar hair, or No. 9, should be meso-5 to correspond to hair No. 5 on the mesothorax of the larva.

The metanotal hairs.

O, *P*, and *R*, or Nos. 10, 11, and 12, should respectively be meta-1, meta-2, and meta-5 to represent the larval hairs on the metathorax of the same designations.

The abdominal hairs.

Proposed designations according to homology or apparent homology with larval hairs of the same notations.	Designations by authors.	Designations by Rozeboom and Knight.
0	*H* and *C'*	9 and 5
1	Float hair and *C*	10
2	*K* and 5	4 on I, 7 on other segments
3	*L*, anterior 2 of II, and 4 of other segments.	5 on I, 6 on other segments
4	*M*, posterior 2 of II, and 2 of other segments.	4
5	*S*, *B* and *A'*	8
6	*A* and *U*	1
7	*T*, first No. 1 of II, and 7 of other segments.	15
8	Second 1 of II and 1 of other segments.	2
9	*D*	16
10	3 (socket on III–V)	3
12	6	14
13	8	17

To regard pupal hairs *A* and *U* as the equivalents of larval hair 6 or the *lh* (as we propose here) may seem questionable because, while *lh* of I and II are well developed, those on the following segments decrease progressively in length such that No. 6 on VII (of most species) and on VIII (of all species) are very tiny. By contrast, *U* and *A's* of the pupa become increasingly developed from I to VIII, *U* on I being tiny, but *A's* of VII and VIII are nearly always large subplumose tufts. Perhaps this may be explained by the fact that changes in hairs in the process of pupation do not follow the same direction, and that in part at least, it seems development or retrogression of hairs depends upon the usefulness of such hairs. Hair *lh* is evidently most useful to the larva on I and II, just as the *A's* are apparently of greatest utility tothe pupa on VII and VIII; hence, the development of *lh* in reverse direction to that of *U* and *A*. Perhaps the marked increase in size of larval hair 14 when it becomes the so-called superior post-ocular hair of the pupa is similar to the change of *lh* on VII and on VIII.

The illustrations in this paper were drawn by Mr. Eliseo Enriquez, artist of the Malaria Section. These are all original except the one copied from Rozeboom and Knight (for comparative purposes), and that which is reproduced from Baisas (1938) which was also originally drawn by Mr. Enriquez.

CHÆTOTAXY OF THE LARVÆ

The numerical notation for larval hairs of *Anopheles* employed by Puri,[9] Christophers [10] and Rozeboom and Knight (*loc. cit.*) is here adapted for the hairs of *Tripteroides larvæ*. Correlating the hairs of *Tripteroides* with those of *Anopheles* is difficult only on the head and abdominal segments VIII–X. The setal arrangement on the thorax and abdominal segments I to VII is closely similar to that of anophelines. Barraud[11] illustrates and numbers the thoracic chætotaxy of *Tripteroides*. From his interpretation, however, we differ in the case of metathoracic hairs 3, 4 and 5. As shown in Plate 1, fig. 5 of the present

[9] PURI, I. M. Larvæ of anopheline mosquitoes with full description of those of Indian species. Ind. Med. Res. Mem. No. 21 (1931), *Plates VII* and *IX*.

[10] CHRISTOPHERS, S. R. Fauna of British India. Diptera. Family Culicidæ. Tribe Anophelini. *4* (1933) p. 39, *Fig. 10;* and p. 43, *Fig. 11.*

[11] BARRAUD, P. J. Fauna of British India. Diptera. Family Culicidæ. Tribes Megarhinini and Culicini *5* (1934) 36, *Fig. 9g.*

paper, we follow the sequence of numbers according to the arrangement of hairs displayed on the pro- and mesothoraces; i. e., outwardly and somewhat upwardly from 1 to 4, and downwardly to 5.

Contrast in hairs between Groups A and B of subgenus *Tripteroides* is very marked. The majority or at least some of the main hairs in Group A are spines or spinelike, or else very long and stout but single; whereas the dominant hairs in group B are the large stellate tufts. Stellate tufts, when present in Group A, are not predominant, and are of different types from those of Group B. But apart from the major differences between the two groups, there are secondary dissimilarities between species in each group which indicate deviations from the main direction of hair development. For instance, in Group A the shortness of all the hairs, including the *lh* of the abdomen in two species, is about as remarkable as the absence of spines from the thoracic pleural hair groups in another two species, or the very thick abdominal hair 13 in still two other species; or the distinct differences in abdominal hair 1 which can be used to divide the group into three smaller units.

Division between Groups A and B, though recognizable by the general types of hairs composing the thoracic pleural groups, is not clear cut as regards the pleural spines. Such spines are present in all but two species of Group A, and absent in all but two species and three subspecies of Group B. The spines when present are very much thicker in Group A than in Group B.

Four kinds of deviations from the main direction of hair development may be recognized in Group B. Most notable is the presence of one or two spines on the prothoracic pleural plate. New species *m* [12] is unique in having its prothoracic hairs 9 and 10 modified into spines, and this is the only known species which has some of its hairs on the head, less so on the thorax and abdomen, conspicuously flattened. The *powelli* complex is also distinct. While in this the prothoracic hair No. 9 is long and branched as usual for Group B, No. 10 is transformed into a slender spine—similar to a branch of a large stellate tuft though somewhat longer and thicker. A very wide range in number of branches of the stellate tufts is shown by the

[12] The new species and subspecies, of which there are twenty one will be named and described in subsequent papers. Here these are referred to merely by letters.

powelli complex. The higher number of branches seems associated with dark larvæ, while the low counts occur among pale individuals. The third type of deviation is represented in new species *j*. It has its prothoracic hair 1 on its own plate separate and some distance away from that which bears 2 and 3. Its Nos. 5 and 6 are branched into two or more; the meso- and the meta-hair 1 are not stellate but tiny with two or more branches, sometimes single; while its meso-13 differs from those of all the others in being long and single. Its abdominal hair 12 is also unusually long and prominent. The fourth type which embraces the majority of Group B (perhaps best represented by *dyari*), does not have any spine on the thoracic pleural plates, no hairs are distinctly flattened, and the variation in number of branches in the stellate tufts does not seem as wide as in the *powelli* complex.

The larva of the only known species of *Rachisoura* in the Philippines has its own pattern of hair development; is quite easily separable from those of subgenus *Tripteroides*, and differs markedly from known larvæ of Australasian *Rachisoura*. Its adult is different from all known *Rachisoura* in being ornate.

The head.—Assuming, as commonly accepted, that the arrangement of hairs in *Anopheles* is the most primitive and therefore the most "fixed," the changes in position of hairs among culicines may be better understood from a comparison with anophelines. Thus compared, it becomes evident that the differences between the hairs on the head of an anopheline and a *Tripteroides* larva are more in types and arrangement rather than in actual number. For while an *Anopheles* has twenty one pairs on the head, a *Tripteroides* has nineteen. Only the post-clypeal or No. 4, and that which arises near the apex of the maxillary palp or No. 16 are not represented in *Tripteroides*.

On the pre-clypeal plate of an anopheline larva are located only two pairs of hairs—the inner pre-clypeal or No. 1, and the outer pre-clypeal which is not given any numeral designation by authors probably because it is not used in classification. There are constantly four pairs on the pre-clypeal plate in Group A *Tripteroides*, but there may be four, three and a half, or three pairs in Group B. This is because in Group B the innermost pair is variable in position, one or both members of the pair being on the fronto-clypeal plate in some species. Regardless, however, of the instability in

position of certain hairs, the pre- and fronto-clypeal plates together bear a total of eight pairs of hairs in all known Philippine *Tripteroides;* nine in *Anopheles.* Hence, actually only one pair is missing from *Tripteroides.* Because of the evidence of movement or tendency to move indicated by the innermost pair, it seems probable that other hairs have also moved, but have become fixed in their new positions. Fronto-clypeal hairs *A, B* and *C* of culicines, which authorities regard as the equivalents of the frontal hairs in anophelines, are good examples of those which have assumed different fixed positions. From this, it seems reasonable to consider two of the pairs on the pre-clypeus of *Tripteroides* represent two of the clypeal hairs in *Anopheles.*

The thick preclypeal spines apparently correspond to No. 1 hair in *Anopheles.* The long, slender pair directly inner to the preclypeal spines in Group A, but variably located above or posterior, though also internal, to the spines in Group B, appears to be the equivalent of the inner clypeal hairs or No. 2. Some distance posterior to the preclypeal spines, very close to the dividing line between the pre- and fronto-clypeal plates are two tiny pairs. Very often they are not visible because of the dark background specially when the feeding brushes are infolded, and because they are tiny and closely appressed (bent downwardly) to the preclypeal plate. The outer of these two seems to be the equivalent of the outer preclypeal in *Anopheles,* more so because of its similar position, and in two species it is flattened like those in many anophelines. The inner pair seems to be the representative of the outer clypeal hair (or No. 3) of *Anopheles.* If considered independently of anopheline notations, the innermost pair should be designated No. 1; the preclypeal spines, No. 2; the inner of the tiny pairs, No. 3; and the outer (outermost of the four pairs), No. 4. But if homology or apparent homology is given primary consideration as it should be, the preclypeal spines should be No. 1, the innermost pair No. 2; No. 3 should be as it is; and No. 4 may be left as such, for the sake of convenience, since it does not seem to represent the post-clypeal or No. 4 of anophelines.

While hair *A* of the fronto-clypeus is fairly fixed in position in all culicines we have examined, *B* and *C* are not. Among those species which have these three hairs in straight line, or where the line is not very badly broken, it is not difficult

to determine their correlation with the frontal hairs of *Anopheles*. But where one pair is very much forward or far behind in position, the usual method followed by authors is to regard the most anterior pair as *B*, regardless of whether this is internal or external to *C*. This seems erroneous when the most anterior pair is also the most internal, because (in *Tripteroides* at least) the movement of (clypeal) hairs seems forward (or backward) instead of inward or outward, although certain hairs (the sutural) manifest both types of movements. The great majority among known species of Philippine *Tripteroides* have the most anterior frontal pair also the most internal; in one or two this is directly anterior to what in the usual method will be considered *C*. We propose, therefore, to regard the most external pair as *A;* the most internal (in the majority of species) as *C*, and the remaining pair, wherever it may be, as *B*; or No. 5 for *C* (most internal), No. 6 for the next or *B*, and No. 7 for the most external or *A*. No. 5 arises at the very (anterior) border of the fronto-clypeal plate in some species of Group A; a little behind that point in others. It is single in some, branched in others. Group B differs in having hair 5 much more posteriorly located. No. 6, is more or less at the same level with 7 in Group A, usually more posterior in Group B. This is fairly long, slender, single in all species except in n. sp. *j*. Hair 8 or the sutural or *e* of authors is much more anterior and internal in position in Group A than in Group B; it is even internal though posterior to 6 in n. sp. *b*. It is shorter than the other fronto-clypeal hairs, and branched except in two species.

Hairs on the epicranial plate.—The trans-sutural, or No. 9, is similarly located as in anophelines. This is rather weak and usually branched, non-diagnostic. No. 12, or the sub-antennal, hair is more posteriorly located, branched in all species, but very short in Group A; fairly large tuft in Group B. The sub-basal or post-mandibular hair (No. 13) is more ventral, often at the same level with 12. It is usually single, distinctly flattened in new species, *m*. The orbital (No. 14) is laterally placed as in anophelines, weak, non-diagnostic. No. 15, or the infra-orbital, is farther forward, sometimes a little away from the anterior margin of the imaginal eye. These two hairs are seldom useful in classification. The post-maxillary hair (No. 18) is very weak, single or split into two or more branches in Group A, but fairly long in *microcala* and

nepenthicola, these two having 13 and 15 stronger than in other species of the group. On most species of Group B hair 18 is closer to the mentum in position. This is weak or moderately large, but very large in two of the undescribed species, *m* and *n,* where it constitutes the most developed hair on the head. The submental or hair No. 20 in Group A is at approximately the same location as that of anophelines but it is very much posterior, close to the rim of the epicranial plate in Group B. It is branched in all species, weak in Group A, slightly more developed in Group B.

Other hairs on the head.—No. 10, or that at the tip of the antenna, is moderately long and stout, single. No. 11, or the shaft hair, arises not far from the apex of the antenna, fairly long or moderately short, single. The hair which springs from the basal piece of the maxilla, or No. 17, is weak, single or branched in Group A; a fairly stout though small tuft in most species of Group B. This hair frequently appears as if it arises from the base of the maxillary palp because the suture dividing the basal piece from the palp is often not well defined. Hair 19 is fairly long, stout, usually single in both groups; it is the strongest ventral hair in some species of Group A. The hair which arises near the apex of the maxillary palp, or No. 16, is not present in *Tripteroides.*

The thorax.—There are fifteen pairs of hairs on the prothorax of *Tripteroides* larva, which conform closely in arrangement to those of *Anopheles* and may similarly be numbered from 0 to 14. Only fourteen pairs are on the mesothorax and thirteen on the metathorax. No. 13 is very weak or absent on the mesothorax of two species in Group A, but No. 14 is present as usual.

Between Groups A and B, the contrast in hairs of the thorax is about equal to that of the abdomen, and certainly more marked than that of the head. While the tendency of the main thoracic hairs of Group A is to become thick spines, or spine-like with a few branches, or else very long and stout, but single, those of Group B tend to become large stellate tufts with many branches. The branches usually vary from about ten to over thirty, of fairly uniform lengths. When large stellate hairs are present in Group A, the branches are usually markedly different in lengths, more stout, taper distinctly from about the middle to the tip, the apex being blunt or jagged,

coarse. The branches of the stellate tufts in Group B are more slender, hardly taper toward the apex except of those like No. 3 of the prothorax which end in finely drawn points. More often, however, as in the majority of the tufts, the branches terminate into a single or double or triple fairly coarse non-divergent points. Fraying or barbs are usual in all the principal hairs or spines of both groups. Nos. 0, 3, 4, 5, 7, 13, and 14 of the prothorax, Nos. 1, 8, 13, and 14 of the mesothorax, and Nos. 1 and 13 of the metathorax are large stellate tufts in Group B, but are either spines, spinelike, tiny or very long and prominent in Group A. No. 7 of the meso- and metathorax are thick spines of varying lengths according to species, but that on the metathorax is normally split into two or more coarse points in Group B; constantly single in Group A. Two new species of Group B have the mesothoracic spine (hair 7) rather weak, often branched, its small tubercle, unlike those of all other species, not fused with the plate of No. 6. On the other hand, the mesospine of new species *d* is quite long but not very thick, nearly like a thick normal hair. All but one species of Group A have No. 10 (of the pleural group) on the pro- and meso-thoraces modified into thick short single spines; in two species Nos. 9, 10 and 12 of the three thoracic segments are reduced to short thick spines. But new species *d* and *g* (Group A) have No. 10 long and normal. Except in new species *m*, Group B has No. 9 long and branched on the three thoracic segments; No. 10, outside of the *powelli* complex, *dvari*, and two new species, is about as long as 9 but single on all segments. No. 12 is similar to 10 though usually longer on the pro- and mesothorax, but always more slender and very much shorter on the metathorax. Prothoracic hairs 9 and 10 of an undescribed species *m*, are spines of moderate lengths and thickness, 10 somewhat exceeding 9 in both respects. These are single but comparatively much less stout than the pleural spines in Group A. These are among the most marked departures from the general direction of hair development in Group B, which are equalled by the absence of spines from the thoracic pleural hair groups in two species of Group A.

Prothoracic hairs 1 to 3, otherwise known as the shoulder hairs, arise from a single common plate in nearly all species of both groups. The same is true with 5 to 7. Exceptions to these are distinctive specifically. Such as in new species *j* where hair No. 1 is on its own plate separate and some distance away from

that which bears 2 and 3; and in an undescribed species, *e*, which has its hairs 1 to 7, sometimes 0 to 7, on a common conspicuous plate. Two species of Group A have pro-13 and 14 on a single plate. Sometimes hair 4 in an undescribed species, *d*, has the tubercle attached to the plate from which 5 to 7 spring.

On the mesothorax only the plates of 6 and 7 are fused; but in an undescribed species *j*, these are on separate small tubercles. Again this species is unique in having meso-13 nonstellate, i. e., long and single. Unlike that on the pro- or the metathorax, meso-6 is not internal to 7, but closely anterior or external to it.

Hair 6 also arises from the large tubercle bearing the spine, or No. 7, of the metathorax in all species of Group A, and in the only *Rachisoura* known locally. The point of attachment, however, in *Rachisoura* (undescribed species, *i*) is at the very base of the tubercle some distance from the base of the spine itself. In species where 6 is not so attached, it is also located close to this point.

THE INDIVIDUAL HAIRS

Hair O.—Found only on the prothorax, is a tiny tuft with from about six to over twenty branches, and situated close to the shoulder hairs in Group A; a large stellate tuft, though not quite as large as the other stellate hairs, situated more or less directly behind hair No. 4 in Group B.

No. 1.—Spinelike, variable in length according to species, single or split into two on the prothorax of Group A; either more or less like this on the meso- and meta-thoraces, or that on the mesothorax is very long, single, or as in new species *d*, this is a tiny tuft on both the meso- and meta-thoraces. In Group B, No. 1 is a large stellate tuft on all thoracic segments, the branches stiff, terminating in single, double or triple points, except in an undescribed species, *j*, which has No. 1 of the meso- and meta-thoraces slender, weak, split into two to about half a dozen branches, sometimes single.

No. 2.—Invariably single, slender on the prothorax in all species of both groups; about the same on the mesothorax, but branched on the metathorax (except in one species) of Group A; nearly the same on the meso- and meta-thoraces of Group B, though occasionally branched on metathorax.

No. 3.—In Group A single, shorter than 2 on the prothorax; longer, single or branched on the meso- and meta-thoraces.

This is stellate on the prothorax of Group B, often slightly larger than 1, and with the branches ending in fine-drawn single points; usually quite long but single on the mesothorax; also single but much shorter on the metathorax.

No. 4.—In Group A single, usually equal in rank to No. 2 on the prothorax, about the same on the mesothorax, a tiny tuft on the metathorax. In Group B a stellate tuft, like No. 1, on the prothorax, stellate but smaller on the metathorax, single, slender on the mesothorax.

No. 5.—In Group A either spinelike, similar to No. 1 or much longer, with fine-drawn tip on the prothorax; invariably long, single on the mesothorax; but tiny, single, branched on the metathorax. In Group B long, slender, single on the prothorax, similar but longer on the mesothorax, stellate tuft on the metathorax. The only exception is an undescribed species, *j*, which has its pro-hair 5 split into fairly stout branches.

No. 6.—In both groups slender, fairly long, single, on plate with, and internal to, 7 on the prothorax; closely anterior or slightly external to, and on plate with, 7 on the mesothorax; internal to and on plate with 7 on the metathorax in Group A, not on that plate in Group B except in one species. Again undescribed species *j* differs in having pro-6 as strong as, and slightly longer than, No. 5, and having two or more branches; while its meso-6 is on a plate separate from that of 7.

No. 7.—In Group A similar to 1 to 5 on the prothorax; thick single spine, varying in length according to species on the mesothorax; thicker, single, but may be longer or shorter than meso-7 on the metathorax. This is, in Group B, stellate on the prothorax; single, thick spine (though rather small and often branched in two new species) on the mesothorax; thicker, more or less curved toward the apex and usually with one or two shorter branches on the metathorax; the *powelli* complex often has three shorter branches on the metathoracic spine.

No. 8.—In Group A short with two or three relatively thick branches, or a fairly large tuft of six or more branches on the prothorax; invariably a tiny tuft on the meso- and metathoraces. In Group B stellate, as No. 1 on the prothorax, also stellate but smaller and with fewer branches on the meso- and metathoraces.

No. 9.—In Group A long, stout, single, frayed on all segments, except in these species which have this modified into very thick spine on one or more segments. In Group B long, branched,

frayed on all segments, except in new species *m* which has only its meta-9 branched, while its pro-9 is modified into a slender spine.

No. 10.—In Group A modified into very thick spine on the pro- and meso-thoraces, and in certain species also on the meta-thorax; but in two species long, single, similar to 9. In Group B this hair is more slender, single, either about as long as 9 or much shorter. The *powelli* complex, like new species *m*, has this reduced into a slender spine. This unusual peculiarity of the *powelli* complex has not been mentioned before by any of the workers who dealt with *powelli*.

No. 11.—Tiny, single or branched; comparatively larger and with more branches (when branches are present) in Group B than in Group A.

No. 12.—Single, usually longer than 10 on the pro- and meso-thoraces in both groups, but that on the metathorax much less in rank.

No. 13.—Most internal of the ventral hairs, variable. In Group A either fairly strong though short, single or branched, or a tiny tuft on the prothorax; tiny tuft with a few or many branches on the mesothorax (apparently absent in two species); very thick, branched spine on the metathorax of two species; fairly strong with a few to several branches in others. Stellate tuft on all segments of Group B, usually the largest on the thorax, particularly that on the metathorax. But undescribed species *j* is unusual since its meso-13 is a long, single hair.

No. 14.—In Group A, nearly always similar and equal in rank to No. 13 on the prothorax; tiny tuft with a few to many branches on the mesothorax; absent on the metathorax. In Group B this is stellate on the pro- and meso-thoraces, often larger than 13 on the pro-, lesser in rank on the meso-thorax; absent on the metathorax.

ABDOMEN

Arrangement of the dorsal abdominal hairs is closely similar to that of anophelines; the ventral differs slightly. While No. 10 is ventrally located in *Anopheles*, this is lateral, anterior to 8 in *Tripteroides*.

The principal abdominal hairs of Group A, that is, Nos. 1, 5, 6, 9 and 13 of I to VII, and 7 of I and II are usually either thick, spinelike or long, stout, but single. Nos. 1, 5 and 9 are

stellate or nearly so in three species but these are not of the same type as the stellate tufts of Group B. Hairs O, 1, 5, 8, 9, 13 and 14 are large stellate tufts in Group B.

Undescribed species *e* is unique because its abdominal hairs 6, 7, and 9, sometimes also 8, arise from a large common plate on segments I to V.

Marked changes in sizes or make-up of certain hairs on different segments occur in a few species of Group A. Generally, however, most of the principal hairs gradually decrease in size and length from the anterior to the posterior segments. This is equally true, though to a lesser degree, with the large stellate tufts in Group B.

The marked differences in certain hairs of Group A may be used to subdivide the species of the group into smaller units. Thus—

(A) Hair No. 1

(*a*) About equal in rank, though relatively short on abdominal segments I–VII . . . undescribed species *b*, *c*, and *e*.

(*b*) Very long on IV to VII, short or different on I–III or on II and III . . . undescribed species *a*, *d* and *g*.

(*c*) Long on all segments . . . *microcala* and *nepenthicola*.

(B) Hair No. 9

(*a*) A strong tuft with about ten to more than twenty branches on I to IV or I to V . . . undescribed species *d* and *g*, and *nepenthicola*.

(*b*) Thick, single spine . . . undescribed species *c* and *e*.

(*c*) Moderately thick, split into two or more branches . . . undescribed species *a* and *b*, and *microcala*.

(C) Hair No. 13.

(*a*) Very thick but short, single or divided into two or more unequal thick points on I to IV or I to V . . . undescribed species *c* and *e*.

(*b*) Being moderately strong, at least on segment I, branched . . . undescribed species *a*, *b*, *d* and *g*, and *microcala*, *nepenthicola*.

THE INDIVIDUAL HAIRS

Hair O.—Present on I or VII. Invariably tiny, sometimes wanting on some segments of *Anopheles*, but well developed, either thick or spinelike, or large stellate tuft in the majority of *Tripteroides*. It is, however, weak, though not as tiny as in anophelines, in undescribed species *c*, *d*, and *e* of Group A. All species of Group B have hair O large and stellate.

Hair 1.—Present on I to VIII. Variable in Group A, according to species, as well as on different segments of certain species. Large stellate tuft in Group B except in undescribed species *j* where this is rather weak compared with other tufts.

Hair 2.—Absent from some segments or some individuals of all species in Group A. Stellate, large, present on II to VII in Group B. Absent also in what appears to be an unusual kind of *Rachisoura*—newly found, and the only one yet known in the Philippines.

Hair 3.—On I to VIII. Tiny, single or branched; or a tiny tuft in both groups; slightly more developed in some species, or on certain segments than in others.

Hair 4.—On I to VII. Similar to 3, but often longer, in both groups.

Hair 5.—On I to VIII. Spinelike in most species of Group A; long like 6 in others; strong tuft in one; small tuft on I to III but long hair on IV to VIII in one species. Stellate in Group B.

Hair 6.—On I to VIII. Very long, single on I to VI in Group A, much reduced on VII, tiny tuft on VIII. Variable in Group B, but long on I to VII in most species; long only on I to VI in undescribed species *m* and *n*. With at least one of those on I to III split into two equal branches, rarely three. One or more of those on I to V are branched in some species, while some individuals have one or more of those on VI and VII split into branches.

Hair 7.—On I and II nearly as long as 6 with which it arises from a common plate; single in all species of Group A, sometimes branched into two or three in some species of Group B. Very much reduced and on separate plate of other segments, but relatively long in undescribed species *j*.

Hair 8.—On I to VII. Situated on lateral side of segment, anterior to 6 and posterior to 10. Tiny, single, or branched in Group A; much longer, stellate in Group B.

Hair 9.—On I to VIII. More or less similar to 5 according to species in Group A; invariably stellate like 1 to 5 in Group B. When this is stellate in Group A, the branches are markedly unequal in lengths, quite stout, each tapering appreciably from about middle to apex, and terminating into a coarse, jagged or clean-cut point. The branches of the large stellate tufts in Group B are not so unequal in lengths, hardly taper toward the apices, each ending in a single, double, or

triple points. Moreover, the branches are evenly spread (when in the natural position) into a complete circle, or semi-circle; unlike those of Group A which are spread less than 150° at most.

Hair 10.—On II to VII. Tiny, single or branched in both groups. Situated on the lateral side of the segment anterior to 8.

Hair 11.—On I to VII. Tiny, single, but longer than 10; that on VII often branched in both Groups A and B.

Hair 12.—On II to VII. Variable in position on different segments, usually anterior to 11 on II, external to 11 and close to the base of either hair 6 or 8 on other segments. Often single on the more anterior segments, and branched on the others. About the same in either group, except in undescribed species *j* of Group B in which this hair is unusually long.

Hair 13.—On I to VIII. The most anterior of the ventral hairs on segment I, being closer to the thorax than the most anterior dorsal hair, O; but becoming more and more posterior in position on each succeeding segment in Group A; relatively constant in location on different segments in Group B. Very variable in type in Group A as discussed above; large stellate tuft in Group B, being the largest hair on some segments.

Hair 14.—Not found in any species of Group A, or in the only known local *Rachisoura.* Large stellate tuft in Group B; the members of the pair very close to each other, except on VII, where they are widely apart; the pair arises very close to the posterior border of each segment.

Abdominal segment VIII bears only five pairs of hairs, the homology of which is extremely difficult to determine. More for convenience than from any definite reasons, these hairs are proposed to be regarded (starting from the most dorsal pair) Nos. 1, 5, 3, 6, and 13. No. 1 or the most dorsal pair is usually the largest on this segment, but it is a tiny tuft in undescribed species *d* and *e.* No. 5 is the second most dorsal, ranks usually second to No. 1 but longer and more stout where No. 1 is weak. No. 3 is usually a tiny tuft. No. 6 equals 5 in most species. No. 13 is on the underside of the segment below the most ventral comb tooth in Group A, but is on the lateral side immediately posterior to the more ventral comb teeth in Group B. This is strikingly different in undescribed species *j* where it is the largest hair (tuft) on VIII.

The hairs on the siphon and anal segment, like the comb-, pecten-, and saddle-teeth, show group and specific differences, but

these will be dealt with in subsequent papers on classification of *Tripteroides*.

SUMMARY

1. A complete new set of numeral hair designations for the pupa is proposed. This is based on the homology or apparent homology between the hairs of the pupa and those of the larva, such homology being fairly well indicated when the pupa is still in its original position inside the larval skin. The number proposed for each pupal seta is exactly the same as that of the larval hair to which it corresponds. The widely accepted numeral scheme for the hairs of anopheline larva is used and referred to here.

2. A discussion on the elimination, reduction, or increase in sizes, and changes in position of hairs during pupation is given. It is shown that only three of the nineteen pairs of hairs on the head of a *Tripteroides* larva, and only nine of the forty-two pairs on the thorax are represented on the cepalothorax of the pupa. According to this, we consider the postocular hairs as the only ones that remain of the hairs on the head of the larva; the anterothoracic as the representatives of the prothoracic larval hairs; the dorsal and supra-alar as the only two not eliminated from the mesothoracic larval hairs; while the metathoracic larval hairs are represented by the three metanotal setæ.

3. It is also shown that though the great majority of hairs undergo considerable reduction in sizes during pupation, some, like the superior postocular hair and the lateral tufts on abdominal segments VII and VIII, increase greatly in sizes. It is likewise indicated that a hair may still exist in the pupal stage even when already eliminated from the larval stage; just as a hair may not be represented in the pupal stage even when well developed in the larva.

4. Similarly, it is shown that the general similarities in arrangement of pupal hairs between different genera, subgenera, groups and species cannot, in some cases, be a guide to identify the different setæ. This is due to the varying positions of certain hairs in relation to each other. Moreover, the relative positions of some hairs are altered when the pupa is freed from the larval skin, and stretches to assume its normal shape. Abdominal hairs 3, 4, 6, and 8 are specially affected by the stretching of the pupa.

5. Differences in hairs on the head between the larva of an *Anopheles* and that of a *Tripteroides* are discussed and shown to be more in types and arrangement rather than in actual number. Only the post-clypeal hair or No. 4, and that which springs near the apex of the maxillary palp or No. 16 are not represented in *Tripteroides*. Changes in position of hairs are well indicated by the inner clypeal or No. 2 of Group B, subgenus *Tripteroides*. In two species it is located on the frontoclypeus, but in all the others, including those of Group A, this springs from the pre-clypeal plate. Movement or instability in position of this hair is further indicated by individuals which have a member of the inner clypeal pair located on the preclypeal plate while the other member arises from the frontoclypeal plate.

6. The usual method of regarding the most anterior of the frontal hairs in culicines as *B* seems erroneous for *Tripteroides* where this is not only the most anterior but also the most internal. In numeral designation this is No. 5 and should, therefore, be *C* instead of *B*. The hairs on the head are discussed individually.

7. The number and arrangement of hairs on the thorax and abdominal segments I to VII closely resemble those of anophelines. The differences displayed on segments VIII to X are obviously due to the differences in the development of these parts between an *Anopheles* and a *Tripteroides*. The different thoracic and abdominal hairs are discussed individually.

ILLUSTRATIONS

Plate 1

Fig. 1. *T. nitidoventer.* Right half, dorsal side of abdominal segments IV and V, showing larval hairs in solid lines, and pupal setæ *in situ* (dotted lines). a and b = tips of branches of the stellate tufts.

2. *T. microcala.* Left half, dorsal side of abdominal segments V, VI and VII, showing larval hairs in solid lines, and pupal setæ *in situ* (dotted lines).

3. *T.* (undescribe) species *d.* Right half, dorsal side, abdominal segment I of larva, showing larval hairs in solid lines, and pupal setæ *in situ* (dotted lines).

4. *T. monetifera.* Ventral side right half of head showing larval hairs in solid lines and pupal setæ *in situ* (dotted lines). Note the increase in size of pupal hair No. 14.

5. *T. monetifera.* Right half, dorsal side of the thorax, showing the larval hairs in solid lines, and the pupal setæ *in situ* (dotted lines).

6. Dorsal portions of two larval heads showing difference in position of hairs 2 and 5.
   (*a*) left side, undescribed species *a* of Group A.
   (*b*) right side—*Tripteroides nitidoventer* of Group B.

Note.—The diffrent figures are not drawn in the same scale.

Plate 2

Fig. 1. Reproduced from Plate VII of Baisas, showing pupal hair notations slightly modified from the scheme of authors. Represents dorsal side, left half, of a *Culex* (*Culex*).

2. Reproduced from Plate IV of Rozeboom and Knight, showing the numerical pupal hair notations they introduced. Represents *Anopheles farauti.*

Plate 3

Fig. 1. *T. dyari* of Group B. Parts of a pupa showing the metanotal and abdominal hairs. Right half represents the dorsal side; left half, the ventral.

2. *T.* (undescribed) species *m.* Anterior portion of larva showing right half, dorsal hairs; left, half, ventral hairs. The dotted lines represent the visible pupal setæ. Insertion at left of head is an enlargement of part of pre- and fronto-cypeal plates.

3. *T.* larva (undescribed) species *b.* Terminal part of abdomen (lateral view). *ct* = comb teeth; *pt* = pecten teeth; *st* = saddle teeth.

4. Thorax of *Tripteroides* larva, undescribed species *b.* (Left half represents ventral side, right half dorsal side). Note shortness of all hairs.

PLATE 4

FIG. 1. Comb teeth, saddle teeth and pecten teeth of undescribed species *m*.
2. Head of *Tripteroides* larva, undescribed species *b*. (Left half ventral side, right half, dorsal side).
3. *Tripteroides* undescribed species *m*. Posterior portion of larva showing right half, dorsal hairs; left half, ventral hairs. Segments VIII–X from lateral aspect. Dotted lines represent visible pupal setæ.
4. Abdominal segment IV of *Tripteroides* larva, undescribed species (Left half represents ventral side; right half, dorsal side). Note.—shortness of all hairs. *st* = saddle teeth.

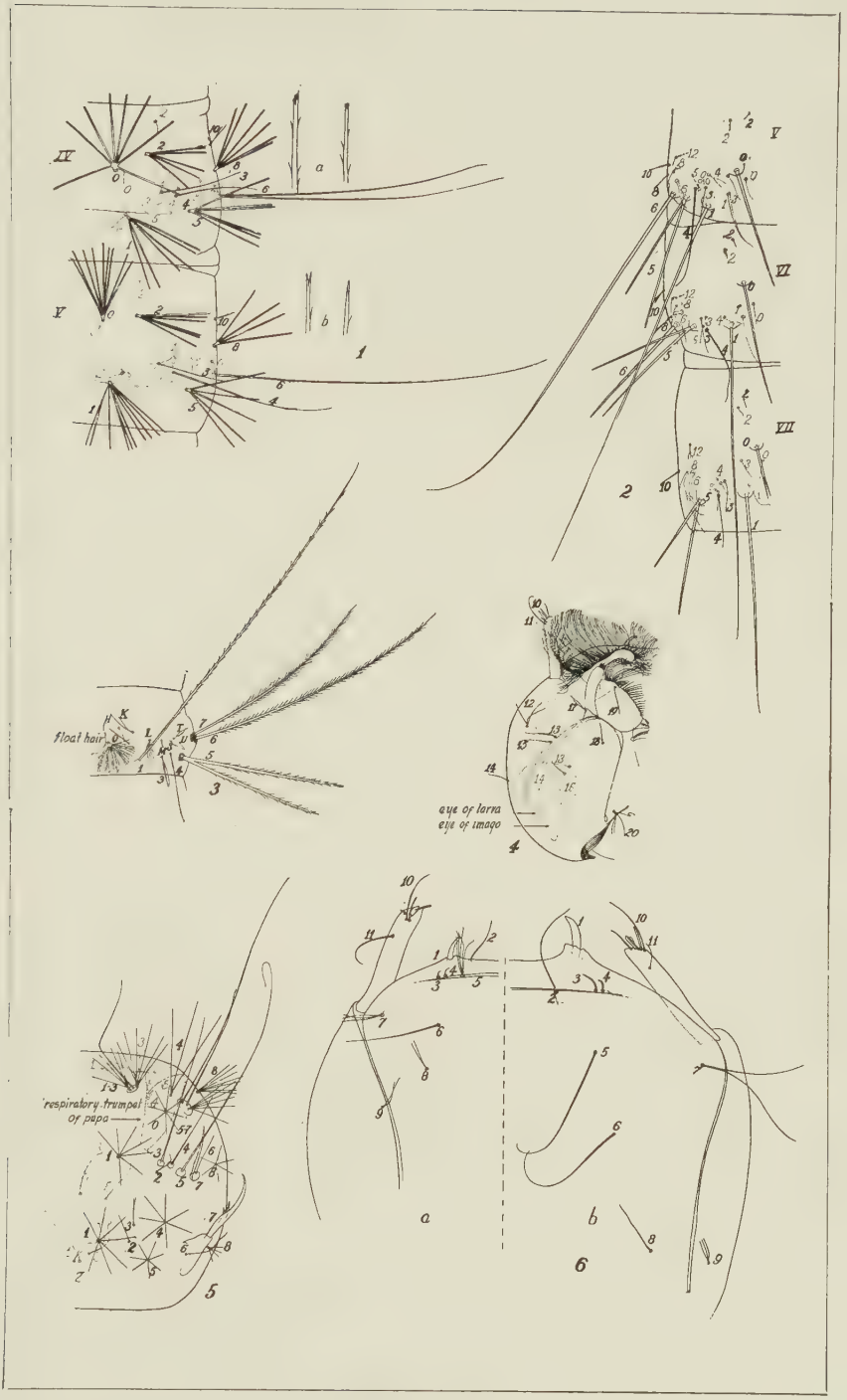
float hair
eye of larva
eye of imago
respiratory trumpet of pupa

PLATE 1.

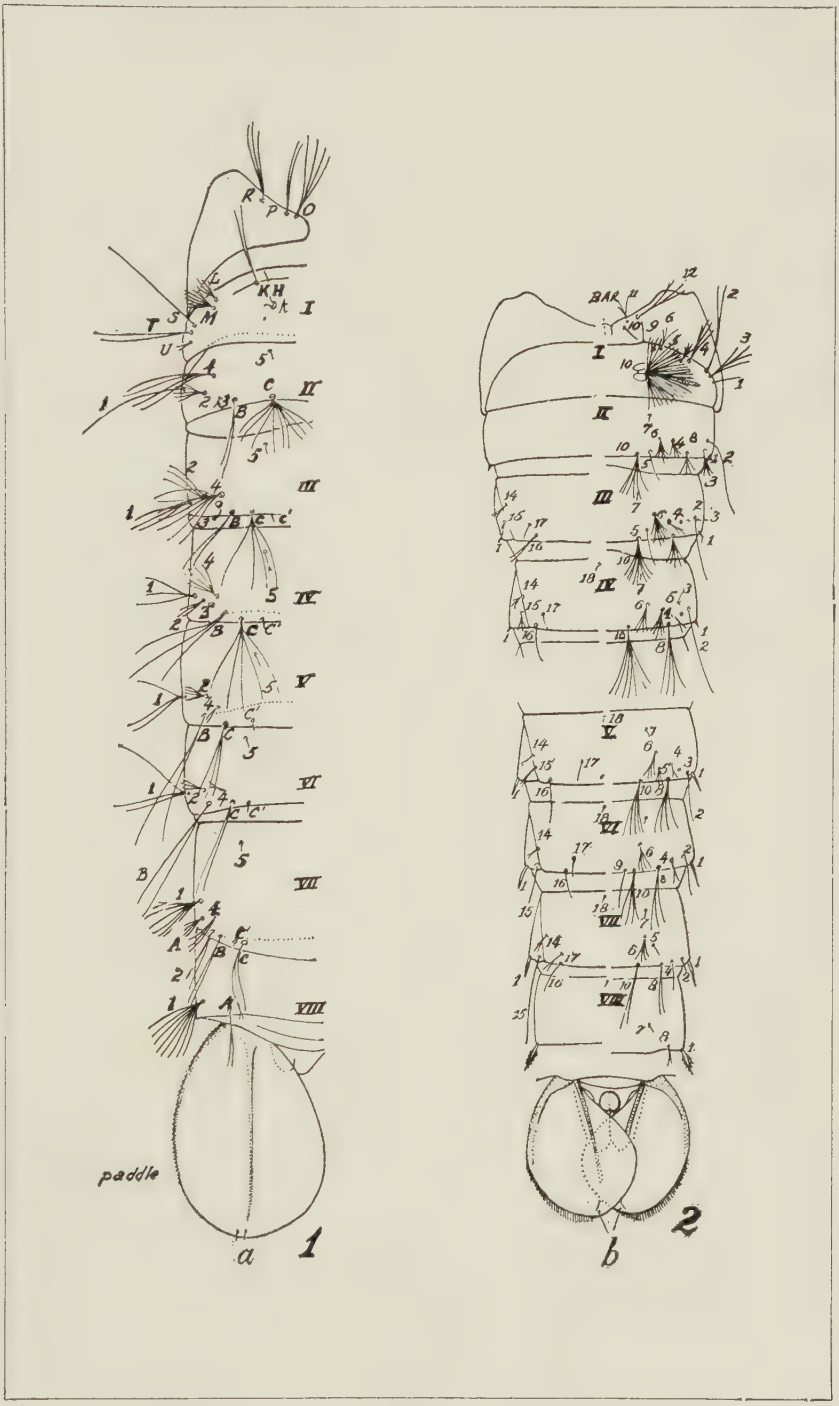

PLATE 2.

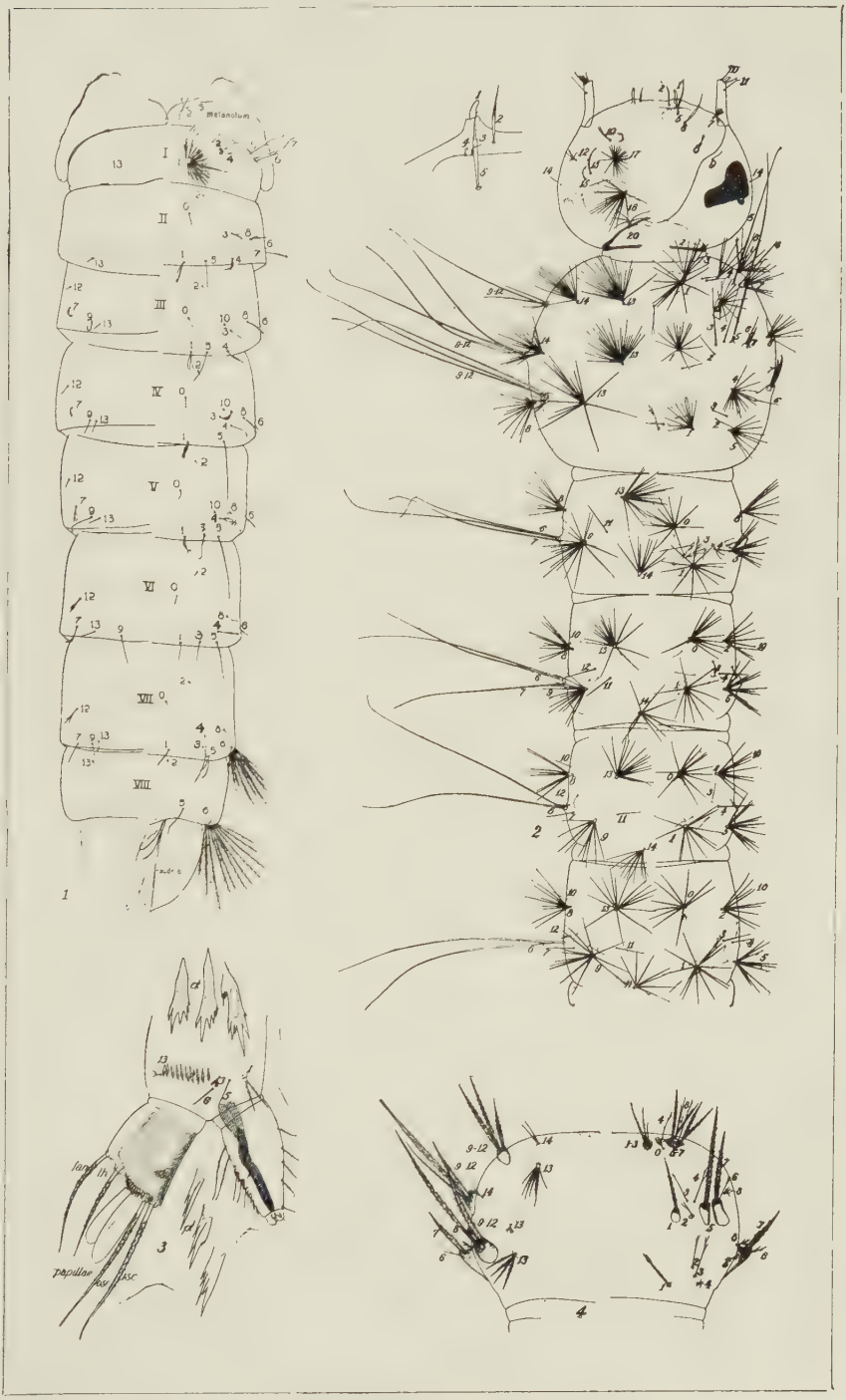

PLATE 3.

PLATE 4.

BLOOD-CHEMISTRY STUDIES IN LEPROSY III. TOTAL CALCIUM, DIFFUSIBLE AND NON-DIFFUSIBLE CALCIUM, ALBUMIN AND GLOBULIN [1]

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The study of calcium in leprosy, which in the past several years had attracted the attention of many leprosy investigators, has been centered chiefly on the question of whether or not in those afflicted with this disease a calcium deficiency exists. The interest in this study undoubtedly had its inception from the clinically manifested evidence of the occurrence of bone salts resorption in the hands and feet of the afflicted, especially in those of the advanced stage. The approach into the problem has been directed mainly to the determination of calcium balance and the total concentration of calcium in the whole blood or serum. However, as will be observed in the review given below, such methods only yielded variable results in the hands of the different workers. Further study of this important problem is deemed necessary.

BRIEF REVIEW OF LITERATURE

Underhill, Honej and Rogert [2] reported that two leper subjects by the balance method, especially the more advanced, manifested a definite tendency to retain calcium. They interpreted this finding to indicate that in the organism a deficiency of this element exists. Along the same line, Boulay and Leger [3] obtained results on three cases which failed to confirm this observation of the aforementioned workers. They reported that the retention tendency was observed only in one and in the other two there was hyperexcretion. From the examination of eleven cases, Reyevski [4] reported the balance as positive but only in those whose leprosy remained stationary. This result, including that which he obtained from blood examination, suggested to him that "during the acute stage of the

[1] Published with the approval of the Director of Hospitals.

[2] Underhill, F. F., J. A., Honej, and L. J. Bogert. Jour. Exp. Med., *32*, (1920), 41–63.

[3] Bouley, A., and M. Leger, Sec. Path. Exot., *15*, (1932), 865.

[4] Reyevski, A. S. Arch. f. Schiff-u Trop. Hyg., *34*, (1930), 651–57.

disease decalcification takes place, blood $[Ca]^{++}$ falls and $[K]^{+}$ rises."

In the examination for total calcium content in whole blood, Concepcion and Salcedo [5] reported their findings on 37 lepers as normal except in a few paroled cases where the calcium content showed a slight abnormal increase. Leman, Liles and Johansen,[6] from the serum examination of 54 cases, failed to observe a deviation from normal in the serum content of this constituent. In similar examination of 47 cases, Wooley and Ross [7] reported this also to be normal. Villela,[8] on the other hand, from the serum analysis of 113 cases, claimed that 51 or about 45 per cent gave values that were abnormally low. He reported this abnormality to occur mostly in the neural type and not in those with lepra reaction. The study on 70 lepers by Cruz, Lara and Paras [9], however, showed that it is in the great majority of those with reaction where the value was observed below normal. Only in the non-reacting did they find it to remain within normal range. These findings appear to have gained support from the works of Badenoch and Byron [10] on 54 cases, and of Herrera [11] on 62 cases. In a study by Nishikawa [12] on 38 cases the serum level was reported to be slightly lower than normal. Otsuka and Yoshinaga [13] reported it normal in the macular form and low in nodular, especially in the neural type.

CURRENT VIEW REGARDING THE STATES OF BLOOD CALCIUM [14]

To state briefly, the universally accepted concept today considers calcium as it exists in this body fluid to be constituted mainly of the diffusible and the non-diffusible form. The for-

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[5] Concepcion, I., and I. Salcedo. Jour. Phil. Is. Med. Assoc., *6* (1926) 154.

[6] Leman, I. I., R. T. Liles, and F. S. Johansen. Am. Jour. Trop. Med., Baltimore, *7* (1927) 61.

[7] Wooley, J. S., and H. Ross. U. S. Pub. Health Rpts., *46* (1931) 641.

[8] Villela, G. G. Int. Jour. Leprosy, *6* (1938) 63.

[9] Cruz, M., C. B. Lara, and E. M. Paras. Jour. Phil. Is. Med. Assoc., *8* (1928) 216–221.

[10] Badenoch, A. G., and F. E. Byron. Trans. Roy. Soc. Trop. Med. Hyg., *26* (1932) 253.

[11] Herrera, R. M. Siglo Med., *95* (1925) 394.

[12] Nishikawa, T. La Lepre *3* (1932) No. 2.

[13] Otsuka, R., and T. Yoshinaga. Trans. 10th Meet. Jap. Lep. Assoc., La Lepre, *9* (1938) Suppl. 32.

[14] For comprehensive review of various works on the subject, readers are referred to Schmidt, C. L. A., and D. M. Greenberg. Physiol. Review, *51* (1935) 297.

mer is regarded as practically all in an ionized state and is the fraction of physiologic and clinical importance, whereas the latter is looked upon as nearly all bound to proteins and believed to be biologically inert. These two fractions are said to account for most, if not all, of the concentration of total calcium in this body fluid.

It can be seen from this concept that the above-cited studies based on the estimation of total calcium content in blood are evidently devoid of clinical significance unless the protein concentration is also known. Further approach to the problem on the basis of this newer knowledge would thus appear to be of no little interest.

PREVIOUS STUDY BASED ON NEW CONCEPT

The examination of the diffusible and the non-diffusible calcium simultaneously with the albumin and globulin in the serum of lepers was attempted only by Wooley and Ross.[7] From a study of 53 lepers, they reported the average for the diffusible and the albumin-globulin ratio as considerably low, increasing abnormally in the non-diffusible and the globulin. Only in a few instances did they find the level approximating the value for the control. Thus, they were led to the conclusion that "the clinically improving cases are accompanied with an increase in the diffusible and the albumin-globulin ratio and a decrease in the percentage of the globulin and the non-diffusible calcium."

The evidence obtained from the above study, particularly with regard to the diffusible, undoubtedly is significant and it is deemed necessary to have this field studied farther. It is with the ultimate objective to help supply the much needed information that the present work has been undertaken.

SUBJECTS

From our previous studies of the inmates of this Colony it was our observation that cases with complication of lepra reaction, especially the febrile type, are most readily susceptible to undergo abnormal changes in the concentration of their serum constituents. Accordingly, in the belief that they would make ideal subjects to meet the present objective, they were taken to constitute most of the cases. Thus, of the 19 selected, 12 were from this group, 3 were those without reaction but advanced, and 4 were also without reaction, but quiescent.

METHODS OF ANALYSIS

Blood of about 20 cc. was drawn from each patient for the analysis of various constituents. After having allowed the drawn blood to clot, the resulting sera were worked out at once. A portion of the serum was used for the determination of the total calcium, albumin and globulin and the rest was subjected to ultrafiltration for the analysis of the diffusible and the non-diffusible calcium. The procedure for ultrafiltration and the colorimetric analysis for albumin and globulin were carried out in detail according to the improved technique described by Greenberg and Gunther [15]. The ultrafiltrate was analyzed for the diffusible according to the gasometric method of Van Slyke and Sendroy [16]. Only those ultrafiltrate giving a negative biuret test were used. For the analysis of total calcium, the Tisdall modification [17] of the Kramer-Tisdall method was employed. The value for the non-diffusible was obtained by substracting the value obtained directly for the diffusible from that of total calcium.

RESULTS

The individual findings obtained in lepers are given in Table 1.

TABLE 1.—*Results obtained in 19 cases of leprosy, showing partitions of serum calcium and proteins.*

Case No.	Milligrams per 100 cc. serum			Grams per 100 cc. serum		Condition of leprosy
	Total calcium	Diffusible calcium	Non-diffusible calcium	Albumin	Globulin	
1	8.60	4.27	3.30	2.54	6.17	With lepra reaction.
2	9.20	6.00	3.20	2.91	5.55	Do.
3	7.80	4.68	3.12	2.54	5.21	Do.
4	8.80	5.40	3.40	3.45	3.78	Do.
5	9.23	4.46	4.77	5.73	1.88	Do.
6	9.23	5.90	3.33	4.13	2.54	Do.
7	7.60	4.50	3.10	3.21	4.55	Do.
8	8.22	5.96	2.36	2.78	5.05	Do.
9	6.82	5.80	3.20	3.32	4.81	Do.
10	8.45	5.96	2.49	2.54	4.71	Do.
11	9.90	6.10	3.80	4.04	3.00	Do.
12	9.92	5.03	4.89	4.53	3.38	Do.
13	10.70	4.75	5.95	5.20	2.21	Clinically negative.
14	10.30	4.90	5.40	4.73	2.74	Do.
15	9.76	5.58	4.70	4.90	2.44	Do.
16	9.90	5.17	4.78	4.08	3.52	Do.
17	10.30	5.64	4.66	4.52	2.46	Advanced.
18	9.79	5.64	4.15	4.42	2.22	Do.
19	9.30	6.20	3.10	4.40	3.09	Do.

[15] Greenberg, D. M. and L. Gunther. Jour. Biol. Chem., *85* (1920–30) 491. Greenberg, D. M. Jour. Biol. Chem., *82* (1929) 545.

[16] Van Slyke, D. D., and J. Sendroy. Proc. Sec. Exp. Biol. Med., *23* (1926) 167.

[17] Tisdall, F. F. Jour. Biol. Chem., *56* (1923) 439.

To facilitate comparison, the maximum and minimum limits and the average value taken for the control and those obtained for the three groups of leprous cases are arranged in Table 2.

TABLE 2.—*Figures from Table 1 compared with control arranged to show only the minimum, maximum and the average.*

Constituents	Control			Reaction cases		
	Min.	Max.	Ave.	Min.	Max.	Ave.
	mg.	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
Total calcium	9.0	11.0	10.0	6.82	9.92	8.65
Diffusible calcium	4.2	6.8	4.96	4.27	6.1	5.33
Nondiffusible calcium	4.1	7.2	5.07	2.36	4.89	3.41
	g.	*g.*	*g.*	*g.*	*g.*	*g.*
Albumin	3.77	5.24	4.4	2.54	5.73	3.34
Globulin	1.96	3.55	2.63	1.88	6.17	4.35

Constituents	Quiescent cases			Advanced cases		
	Min.	Max.	Ave.	Min.	Max.	Ave.
	mg.	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
Total calcium	9.76	10.7	10.17	9.3	10.3	9.8
Diffusible calcium	4.75	5.58	5.10	5.64	6.2	5.83
Nondiffusible calcium	4.70	5.95	5.21	3.10	4.66	3.97
	g.	*g.*	*g.*	*g.*	*g.*	*g.*
Albumin	4.08	5.2	4.73	4.4	4.52	4.45
Globulin	2.21	3.52	2.73	2.22	3.09	2.59

Total calcium.—An examination of the data compiled in the said tables will show that the serum level for total calcium suffers abnormal reduction only in lepra reaction group. This finds confirmation in the previous study of this constituent by us [19]. Of the 12 cases in this group, 7 or about 58 per cent show values that are definitely below normal. No appreciable difference in the average value can be noted between the different groups except in that with reaction where it is observed to be definitely below normal.

Diffusible calcium.—The serum level of this constituent, both in the reaction group and in the quiescent and the advanced, is, without exception, within the range of normal limits. Compared with the control, the average (Table 2) appears higher in the 3 groups of cases, the advanced having the highest, next the reaction group, and least the quiescent.

Non-diffusible calcium.—In the case of this constituent, the serum level in 10 out of 12 reaction cases (about 83 per cent) is subnormal, and only in 1 out of 3 cases (about 33 per cent) in the advanced group where it is found to be abnormally low. In the quiescent group, it is all well within normal range. The average, compared with the control, is practically

the same as that in the quiescent and appreciably low both in the advanced and the reaction groups.

Serum proteins.—The fate for the albumin in general appears to follow the same trend as in the case for total calcium, that is, abnormal reduction only in cases with lepra reaction complication, otherwise normal. Of the 12 cases in this group, 10 or about 83 per cent, show values that are definitely subnormal. The average in this group is markedly low, but in the other two groups it does not appear to differ appreciably from the normal. In the case of the globulin, its serum level is raised markedly above normal in 9 of 12 cases (75 per cent) in the reaction group and practically normal in the quiescent and advanced groups. The average value is definitely above normal in the group with reaction and practically normal in the other two groups.

DISCUSSION

Before discussing the results just presented it may be well to touch first upon those evidences which have given rise to the contention of the existence of a deficiency in calcium in this disease. These are: (*a*) the finding of Underhill and his associates,[2] based on calcium balance measurement, of a definite tendency of the organism to retain this element, with the apparent support it gained from the work of Reyevski;[4] (*b*) the abnormal reduction in the serum total calcium level [8, 9, 10, 11, 12, 13]; and (*c*) the low finding in the serum diffusible.[7] As regards the first, it should be realized that the various data reported in this study, besides the fact that they lack complete accord and are in conflict with that obtained by Boulay and Leger,[3] are only based on two cases. It should further be reckoned that the application of the balance method to the investigation of human subjects, especially in diseased conditions, could not likely yield decisive results, even if it is carried out with the most scrupulous care, because of the complicating factors involved. The situation in the case of that revealed from total calcium examination is still less convincing because on the basis of the newer knowledge, the claims cited, besides being also variable and quite in conflict with those of others,[5,6,7] could not have clinical meaning unless the serum protein concentration is also known.

Coming now to the diffusible, the present study, as seen from the results just presented, failed to confirm the low

finding reported by Wooley and Ross for this constituent. As already pointed out, not a case of the nineteen patients subjected to the analysis, irrespective of the presence of major complication like lepra reaction and the advancement of the disease itself, was its level found to have undergone abnormal lowering. But this disagreement, as will be noted, is more apparent than real and in fact their finding for this constituent can serve, instead, to establish the results obtained in this work. Thus, if on re-examining the data of the aforementioned workers the low normal limit of 4.2 for the diffusible is used instead of the 5.5 which the said workers took for this purpose, 43 or 81 per cent of the 53 cases whom they subjected to the examination will be found to have values that fall well within the range of normal, and only in 10 or 19 per cent where this drops below normal. But even in these cases, 5 will be seen to approximate closely the limit of normal and only 3 would be in the zone which, according to the experience of other investigators, could only be compatible with the existence of tetany that is caused by parathyroid insufficiency. Whether the marked abnormality in these latter cases is caused by the existence of an actual calcium deficiency or due to faulty methods in the analysis, this paper will not attempt to discuss. It may seem pertinent, however, to mention that in the absence of tetany, low values could result from a poorly prepared membrane that has been utilized in the ultrafiltration or compensation dialysis and from a membrane that has been badly impregnated through repeated use. Which of the two limits just considered could justifiably represent the actual or at least approaching the true value is of course of importance to determine. For this matter, we can only state for the present that we find justification in the adoption of 4.2 from the consideration of the following: (*a*) our previous survey on serum total calcium and serum proteins of those residing in this Colony yielded values which revealed to be quite comparable with those reported in the literature, thus showing that climatic factor, etc., do not have any appreciable influence, if at all, upon the concentration of these constituents. It does not seem likely, therefore, that the diffusible low level would also deviate appreciably, if at all, from this value; (*b*) it represented a much larger series of different groups of normal individuals than that in the value taken by Wooley and Ross. In the latter the normal individuals that it represented can be said to be composed of practically one class of such individuals whose standard of

living, etc. are above average; (*c*) it is the widely accepted value among investigators; and (*d*) it is in accord with that obtained from any dialysis experiments by various investigators and from that obtained by the use of direct biologic method.

It could be seen plainly from the above that there was no valid reasons to consider this serum constituent to be deficient in this disease as Wooley and Ross would lead us to believe. Theoretical considerations of the mechanism that is involved in the equilibrium relationship between calcium and proteins, which the recent studies of McLean and Hastings [18] have proved to exist in this body fluid, would seem to provide means by which this contention could find further support. To facilitate discussion on this point let us for the moment touch briefly upon this mechanism. From the works of the above-cited investigators it appears that the calcium ions, protein ions and the calcium salts of proteins, behave as if there was equilibrium between them; that this behavior appeared to obey mass action law and could be expressed by the equation

$$\frac{[\text{Ca}]^{++} \times [\text{Protein}]^{=}}{[\text{Ca Proteinate}]} = \text{K} \qquad (1)$$

in which K varies with the pH of the normal serum. Now, on the basis of the conditions by which the constituents under consideration in this study are known to exist, the application of the above equation would justify limiting the determining factors for the equilibrium, mainly, to the diffusible calcium, the non-diffusible calcium and the albumin. The equation, accordingly, could evidently be represented by

$$\frac{[\text{Diffusible Ca}]^{++} \times [\text{Albumin}]^{=}}{\begin{matrix}[\text{Non-diffusible Ca}] \\ (\text{Ca-albuminate})\end{matrix}} = \text{K} \qquad (2)$$

As may be seen then from this latter equation,[19] in calcium deficiency, mass action law would have us expect the level of both the diffusible and the non-diffusible to come down low. But as

[18] McLean, F. C., and A. B. Hastings. Jour. Biol. Chem., *108* (1935) 285.

[19] The present data could not be treated strictly quantitatively, in the first place because they are not expressed in molecular concentrations which is a requirement of the expression, and secondly, they are believed to approximate only the conditions. Necessarily, therefore, they can at best be discussed qualitatively and this is believed sufficient to meet the purpose of this study.

the results show, while the non-diffusible actually suffered abnormal reduction in accordance with this expectation, the diffusible level failed to have undergone similar fate. It can thus be seen that the contention in the existence of such a deficiency can neither, on this basis, be satisfactorily explained. Neither could the data of Wooley and Ross be, because, even granting for the sake of argument, that their finding for the diffusible was really low, tne non-diffusible, which should also be low as expected to be found in conditions where there is such deficiency was shown, instead, to be increased abnormally.

Now, to view the results from another angle, equation 2 can be seen to help explain satisfactorily the fall in the level of the albumin as the one accountable for the reduction that occurs in the non-diffusible. The results obtained in this study appears to help affirm this assumption. Assuming this to be the case it becomes quite plain that the low results obtained in the total calcium could be due to the fate that befell the non-diffusible, the diffusible having shown to have not undergone abnormal lowering. As for the increase in the globulin, it may be surmised that this probably, considering the well-known functional value of this constituent in the body defense mechanism, is a product elaborated at the expense of the albumin in an effort to overcome the ill-effects caused by the lepra reaction attack and such other causes.

As can be noted from the discussion the reference to the equation was practically limited in explaining the deficiencies. While it may not be entirely out of the scope of the present work, it is thought worthwhile considering also the fact that from the equations given, by increasing the total concentration of protein, the reaction trend would be toward increasing the concentration of the constituents that suffered deficiencies and this tendency will continue to be so with increase of supply of the required substance until the dissociation constant of the equilibrium has been restored to its original state. It thus appears quite suggestive that protein therapy or adequate protein diet, or both, may prove beneficial in the treatment of lepra reaction cases where the above-cited deficiencies are found to occur mostly. It may be pointed out that calcium drug may have similar effect in the matter of restoring the equilibrium dissociation constant by elevating the level of the non-diffusible and may therefore also prove beneficial. As a

matter of fact the experience [20] in this Colony has shown this to have really appreciable ameliorating effect in the treatment of the reacting cases. However, as already discussed above, the focus of disturbance is not in the calcium but in the protein component system and for this fact protein may prove to be more effective.

SUMMARY AND CONCLUSION

The present investigation involving analysis of the serum for its content of total calcium, diffusible calcium, non-diffusible calcium, albumin and globulin in nineteen lepers has been undertaken with a view to help solve the long controversial question of whether or not calcium deficiency exists in leprosy.

The inadequacy of the data compiled from previous studies of the earlier investigators based on the determination of calcium balance and of the concentration of total calcium in the whole blood or serum was discussed.

In this study the presence of major intercurrent diseases, like lepra reaction and the advancement of the disease itself, was shown to have no appreciable influence, if at all, upon the normal level of the diffusible. The low results observed by Wooley and Ross for this constituent were shown to be more apparent than real and that they rather serve, instead, to establish the finding reported in this study.

The great majority of the cases with lepra reaction revealed a general abnormal lowering in the serum level of total calcium, non-diffusible calcium and the albumin and an abnormal shift above normal of the globulin. The non-reacting cases failed to show appreciable abnormal alterations, if at all, in these constituents. The explanation for the conditions found in the reaction was given on the basis of an equilibrium relationship assumed to exist in this body fluid between calcium and proteins.

From the consideration of the facts given in the above discussions, the writer is led to conclude that in leprosy there is no deficiency of calcium, at least in so far as the serum physiologic calcium that is measurable in terms of the diffusible is concerned. The abnormal rise in the level of the globulin

[20] Roxas-Pineda, E., C. Nicolas and C. B. Lara. Jour. Phil. Is. Med. Assoc. (1928), 207.

is believed to be at the expense of the albumin which causes its fall to below normal and this effect upon the latter in turn causes the lowering in the non-diffusible and in the total calcium.

Protein therapy is suggested as worth giving a trial in the treatment of leprosy cases suffering from lepra reaction attack, especially in those manifesting low albumin in the serum.

PHILIPPINE SOLAR SALT INDUSTRY

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Salt production through the solar process has, perhaps, been practiced for centuries in the Philippines and has, through the years, gone through considerable evolution towards more efficient methods in many of the producing provinces. The methods now in use, however, are not as efficient nor are they as productive of a pure salt as the solar salt producing methods practiced in some other parts of the world.

Cox et al (1915), Ablan et al (1940), Montalban (1930), Seale (1914), and Herre et al (1920) all refer to the fact that the poor quality of the locally produced salt has a deleterious effect on the fish preserved with it. Tressler (1920) has shown that calcium, magnesium and sulfates as impurities in salt retard the penetration of salt into fish during curing. Dunn (1946) has shown that herring fillets are struck through sooner during brining if the salt is pure. Hess (1942) has shown that impurities in salt affect the keeping quality of cod press juice. Shelf life of salt fish may, therefore, be extended by the use of pure salt. Tressler (1923) and Phalen (1917) point out that salt for many industrial purposes must be of high purity. Table 1 gives the results of some analyses of local and foreign salts. This table illustrates that the local salt is not as pure as solar salt produced in other areas and suggests that salt of equal quality could be produced here if some changes were made in the present practices.

Table 1.—*Analyses of samples of sea salt*

Radicals	Puerto Rican [1]	California [2]	Bahaman [2]	Manila
	Per cent	*Per cent*	*Per cent*	*Per cent*
Sand and insolubles	0.07	0.008	0.13	0.06
Sulfate (SO_4)	0.97	0.021	1.72	4.07
Calcium (Ca)	0.50	0.025	0.45	0.40
Magnesium (Mg)	0.04	0.000	0.47	1.48
Sodium chloride (Cl) calculated	98.52	99.94	97.23	91.93
Chloride (Cl)	58.72	60.70	59.44	----------
Ferric oxide and alumina (Fe_2O_3 and Al_2O_3)	Traces	----------	----------	----------

[1] Produced by a modified improved Oriental process. This salt had not been washed.
[2] From Tressler, A. K. Bureau of Fish Doc. 884 (1920).

Local methods.—In the solar salt process the first requirements are a hot sun, preferably brisk breezes of low humidity, and large areas of impermeable land near the sea. These requirements are found in several provinces in the Philippines but the industry is for the most part located in Rizal, Bulacan, Cavite, Bataan, and Batangas provinces. In these provinces, the so-called, improved Oriental process is practiced. In this process, as employed in the Philippines, areas used as fish ponds in the wet season are used to produce salt during the dry months.

Most of the fish pond area is employed for concentration ponds where the seawater, 10 to 20 centimeters deep, is evaporated down to a more or less saturated solution. Usually, for ease in operation, this is done in three or more separate ponds. The raw seawater may be evaporated in the first pond from 3.5°Be to 4.5°Be, in the second to 6°Be, in the third to 8°Be, and in the fourth to about 12 to 15°Be. In the concentrating ponds, the sediment settles, and the iron sulfide, calcium carbonate and some of the calcium sulfate are deposited. This brine, at about 15°Be, is then dipped with buckets into crystallizing ponds where it is evaporated almost to dryness and the salt recovered. These latter ponds are about 5 meters by 7 meters equipped with board sides and tile bottoms, and usually represent from 1/10 to 1/15 of the entire area at the salt works.

Everyday, during the season, the ponds are filled to a depth of about 1 cm. and late in the afternoon after each day of evaporation the salt is raked into a pile on the side of the crystallization bed and the pond refilled. This process is continued throughout the season, without any change, until the brine level builds up with a heavy brine containing a large percentage of the magnesium salts. When this happens, the salt producer will probably let the pond go for a day or more without adding fresh brine, and will then, after harvesting the salt, splash out of the pond the remainder of the brine. Owing to the high magnesium content, this method of handling produces a most inferior product. It is even possible at times to find crystals of pure magnesium sulfate intermixed with the salt. As explained above, it is the common practice of the salt producers in the Manila area to fill the crystallization beds with brine of 12 to 17°Be which is the point at which calcium sulfate begins to precipitate, and thus practically all the calcium sulfate is found

in the final product as an impurity. Further, it may be noted that the practice of using an unsaturated brine in the crystallizers results in a lower yield since a portion of each day is spent in evaporating the brine to a point where salt will begin to form at 25°Be.

A great part of the salt produced is sold as it is harvested, but a considerable portion is stored, both by speculators and producers, in the hope that there will be a better market during the non-producing season. During the period of storage, up to twenty per cent of the weight of the salt is lost owing to the moisture being absorbed from the air in such quantities that the piles of salt, literally, drip. This loss could be lessened by producing a purer salt which would have a lower percentage of the highly hygroscopic magnesium and calcium salts.

In the provinces of Ilocos Norte, Ilocos Sur, La Union, and Pangasinan, salt is prepared by the old Oriental leaching process. Their process is described by Tressler (1920). Ablan et al (1940) in an extensive field study of this process came to the general conclusion that this method of salt production was not economic and suggested, that in certain places, the improved Oriental process might be profitably introduced.

California practice.—The American salt making process in general is similar to the improved Oriental process but the details of the process vary greatly. The operations are conducted in various ponds. These are: (1) the storage or intake pond into which the salt water is received from the bay, (2) concentrating ponds, and (3) crystallizing ponds.

Some of the works have automatic gates which open when the tide is at flood and close when it begins to ebb. The salt water remains in the intake pond for various lengths of time, and is pumped into the concentrating ponds to a depth of 25 to 50 cm. before the next sea water is taken in. It then goes through the different ponds, becoming more concentrated, until it reaches the crystallizing ponds. It is run into these, when it reaches a strength of 25°Be, to a depth of 15 centimeters or more. This depth of brine causes the deposition of large crystals which, over the extended period of evaporation, grow into massive solid crystals of nearly pure salt. Here the brine evaporates until it has reached a density of 29°Be, at which time the bittern is either discarded or evaporated in other ponds to a density of 32°Be. This salt, formed from

the heavier bittern, is less pure. The process is repeated until the end of the season or until a thick enough bed of salt is obtained to make the harvesting economical.

The sea water is usually pumped from the intake pond to the concentrating ponds, through which it flows by gravity. The brine may then flow by gravity or be pumped into the crystalizing ponds, depending on the lay-out of the land.

All of the ponds have mud bottoms and often a split is made in the harvesting. That is, all the salt except the bottom 5 centimeters will be taken first and then the bottom part will be removed and used where a cheaper salt can serve. In the modern plants, machinery is now used to remove the salt from the beds. Often the harvested salt is washed with brine from the concentration ponds and with fresh water just after it is harvested. By this treatment some of the producers get salt of over 99.5 per cent sodium chloride content. It is possible to get a relatively pure product with this simple washing process because the crystals are large and solid. Impurities are only on the outside surfaces of the crystals and the mother liquor and washwaters drain free. Further, in the storage of the large solid crystals under conditions of high humidity, less salt is lost than when storing small crystals.

Experimental results.—Several experiments were conducted on a salt farm in Las Piñas, Rizal. The first experiment was designed to determine the effect on purity of salt obtained from brines of different densities. A bed 5 meters by 7 meters was filled to capacity, about 5 cm. in depth. No salt came down until the fourth day and on the 5th day rather large hollow hopper shaped crystals formed. Table 2 gives the analyses for magnesium in the various samples.

TABLE 2.—*Effect of brine density on magnesium content*

Days after filling	Brine density	Magnesium
	Per cent	*Per cent*
4	14	
5	23.5	
6	28	0.51
7	29.5	0.62
8	31.5	2.34
Sample from control pond	39	8.09
	31	0.82

This table illustrates how a somewhat greater purity can be obtained at the lower brine densities, but this reduction in

magnesium content is of too small a magnitude to be of any practical significance. This is because the standard practice under local production methods involving daily harvests results in the formation of relatively small hollow salt crystals. These crystals have a relatively high surface to volume ratio which retains a great deal of the impure mother liquor. Further they are of such shape that the mother liquor does not drain as freely as it would from large solid crystals. Simple washing experiments on these salts also failed because the purity could not be improved enough to make the washing practical.

The failure of the foregoing experiment in developing a method of producing a purer salt led to two series of experiments designed to illustrate how a greater operational efficiency could be achieved. In these experiments one crystalizing pond was filled with the brine at about 14 ° Be—the density at which it is usually added to the crystallizing pond. After it had evaporated to about 25°Be it was pumped into a second pond. In these experiments over a two week period an average daily production of 56 kilograms was realized from the experimental plot, whereas only 38 kilograms were harvested from the control plot. The control plot was operated exactly the same as the regular procedure for this particular salt works. This experiment indicates that for a given total area of salt works it should be possible to reduce the area of crystallization beds by about one third the present space devoted to such use and still obtain the same yield. The area then made available can be used as additional concentration ponds to concentrate the brine to 25°Be. This should result in considerable savings to the operators as the investment in preparing crystallizing ponds is quite high. It should also reduce harvesting costs to some extent.

Conditions affecting rate of evaporation.—It is apparently the belief of the salt producers that evaporation is more rapid from shallow ponds, and also that evaporation proceeds more rapidly over the tile in the crystallization ponds than from deeper ponds with a mud bottom. To determine any bases of these contentions experiments were made in small pans. Clear white enamel photographic pans and black plastic photographic pans were used. The tile was set in mud placed in an enamel pan. In the experiment conducted over a mud bottom an enamel pan was used with about 2.5 cm. of soil. The measurement of evaporation was determined by weighing after eight hours in the sun,

and again after standing overnight. Table 3 gives the results of these experiments.

TABLE 3.—*Effect of bottom surface and depth on evaporation.*

Type of pan and bottom	Initial depth of water	Kg. of water evap. per sq. m.	Kg. of water evap. per sq. m.
	cm.	*8:00 a.m. to 4:00 p.m.*	*24 hrs.*
Tile bottom	1.5	6.0	8.7
Mud bottom	1.5	6.3	8.4
Black plastic	1.6	7.2	8.3
Clear white enamel	1.7	4.6	6.7
Idem.	1.15	4.6	6.4
Idem.	5.2	5.8	8.1
Black plastic	1.15	7.0	8.5
Idem.	5.0	7.0	9.2

These experiments show that the rate of evaporation is not greatly influenced by depth of water at the depths tested when the bottom does not reflect the sun's rays. It is indicated, though, that when the bottom reflects the sun's rays the evaporation proceeds more rapidly from the deeper water. The difference in the rates of evaporation between the experiments with tile and mud bottoms is not considered to be significant. There is, obviously at the depths tested, an advantage in having the bottom of a color which will absorb the heat rays from the sun. The difference in the evaporation for 24 hours between the deep and shallow water levels for the black plastic containers can be explained on the basis of the greater latent heat of the deeper brine at sunset.

Table 4 gives temperature and density variations at various points on a salt farm over the period of most active evaporation. The depths in the various ponds were about 2 cm. in the crystallizing pond and about 4 cm. in the concentration pond and at least 15 cm. in the ditch. It is an interesting observation to note that the temperature of the brine in the ditch was higher at the bottom than at the surface. This is explained by the fact that the brine in the ditch evaporates throughout the day and is then lower in level than the crystallizing ponds when refilled. When additional brine from the last concentrating pond at a lower density is brought in it does not mix with the remainder of the heavy brine in the ditch but just flows in over the surface. The sun then heats the mud bottom of the ditch and this heat is only slowly absorbed by the brine. Actual tests showed that the brine at the bottom of the ditch was of greater density than that at the surface.

TABLE 4.—*Temperature and density value at various places on a salt farm* [3]

Time	Ditch bottom		Ditch surface		Crystallization pond		Concentration pond[4]	
	Temp.	Density	Temp.	Density	Temp.	Density	Temp.	Density
	Centigrade	*Baume*	*Centigrade*	*Baume*	*Centigrade*	*Baume*	*Centigrade*	*Baume*
9:00	36	15	32	15	39	27	37	20
10:00	40	16	35	16	43	28	41	21
11:00	43	16	35	16	43	29	42	22
12:00	47	16	38	16	45	29	43	23
13:00	46	15.5	37	15.5	46	30	44	24
14:00	46	16	38	16	46	30	44	24
15:00	45	16	37	16	39	31	38	25
16:00	43	16	35	16	40	31	38	25

[3] Temperature is in degrees centigrade and density in degrees Baumé.

[4] The concentration pond here referred to was a small tile-surfaced pond, normally used for crystallization.

Table 5 gives the evaporation and rainfall during the salt making season for the San Francisco Bay area and also the corresponding data for the Manila area.

TABLE 5.—*Evaporation and rainfall in millimeters*

Month	San Francisco			Manila		
	Rain	*Evap.*	*Net evap.*	*Rain*	*Evap.*	*Net evap.*
December	----------	----------	----------	63	155	92
January	----------	----------	----------	24	170	146
February	----------	----------	----------	12	200	188
March	----------	----------	----------	18	265	247
April	35.0	86	51	31	280	249
May	29.0	135	106	130	235	105
June	17.0	168	151	----------	----------	----------
July	0.0	198	198	----------	----------	----------
August	0.0	198	198	----------	----------	----------
September	0.0	125	125	----------	----------	----------
October	20.0	75	55	----------	----------	----------
Salt season total	101.0	985	884	278	1,305	1,027

From these data it is seen that there is about 16 per cent greater net evaporation in the Manila area than in the San Francisco area during the salt making season. We may therefore assume on the basis of the weather alone that local conditions are satisfactory for the introduction of the California method. The following disadvantages may be considered, however, in the introduction of the new system:

1. The use of deep brine in all the ponds might make it necessary to use pumps. Lack of electrical power and cost of pumping equipment might make this type of operation too expensive.

2. The problem of displaced labor might be acute in certain producing areas.

CONCLUSIONS

1. The operating efficiency can be increased and the cost of production somewhat decreased by concentrating the brine to the point at which salt begins to form, prior to placing brine in the crystallization beds.

2. Favorable conditions exist for the introduction of more efficient production technics.

3. In order to produce a purer salt the present practices must be considerably modified.

4. Because of the crystal characteristics of Philippine salt, it is difficult to purify it by washing.

5. Within certain limits the depth of the evaporating brine has no significant effect on the rate of evaporation.

RECOMMENDATIONS

1. Serious consideration should be given to the application of the California method of salt production in the construction of new salts works.

2. Old operators should review their production costs and consider the application of more modern methods.

3. Additional experiments should be made demonstrating the feasibility of improved methods under the prevailing conditions.

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STUDIES ON SCYLLA (CRUSTACEA: PORTUNIDÆ), I. REVISION OF THE GENUS [1]

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THREE PLATES

Scylla serrata (Forskal), *S. oceanica* (Dana), *S. tranquebarica* (Fabricius), and the new variety *S. serrata* var. *paramamosain* comprise the group of crabs that are called *alimango* (Tagalog and Visayan), *rasá* (Ilocano), and *alama* (Pangasinan). They are generally regarded as our most valuable crabs, and it is rather strange that we know very little about their biology. The present work has for its aim the following objectives:

(1) To study the biological peculiarities of the animals, so that measures for their propagation can be adopted.

(2) To study the mode of reproduction and the development of the young to the size at which sexual maturity is attained.

(3) To study their bionomics—the economic relations of the different phases in the life history of the crabs.

(4) To show the advisability of enacting wise fishery laws designed for their conservation and proper exploitation.

The work started with the assumption of previous authors that *S. serrata* comprises the only representative of the genus in the Philippines; hence, the external morphological features were not scrutinized very closely. The writer, however, was aware from the beginning of the existence of what apparently was a variety, which fishermen around Manila Bay call *bulik*, meaning motley-spotted. These crabs are characterized by their carapace, abdomen (in female only), and legs being bizarrely ornamented with rather large polygonal pigmented areas having shades of grayish to whitish, the spots bordered by purplish or dark-brown lines. The color markings are more distinct in medium-sized crabs, but in the bigger and older ones the pigmented areas on the carapace become indistinct, owing to their being obscured by deposition of sediments or

[1] This paper proposes the revision of the genus to include three species and one new variety based on external morphology and gametogenesis. More detailed data on spermatogenesis and oögenesis of the different forms will be treated in a subsequent paper.

algal growth which give the carapace a muddy appearance. The general coloration is greenish with shades of brownish gray in some places of the body including the chelipeds and legs. The *bulik* crabs grow bigger than any of the other forms, some specimens measuring about twenty-three centimeters across the greatest width of the carapace.

In some places in Quezon Province the *bulik* group is known as *banhawin,* and the other kinds *mamosain.* For convenience, the two terms are adopted throughout the discussion for grouping the crabs. The *mamosain* group is characterized by the absence of color markings like those found among the *banhawin,* or *bulik.* Some whitish spots may be present on the carapace and legs, but, generally, they are indistinct and are mostly confined on the last legs. The general coloration in *mamosain* is something like a combination of rust-color (ferrugineous) and dark brown; the shades of color may vary, but the general greenish tint, characteristic in *banhawin,* does not appear. The *mamosain* (referring only to *S. serrata*) as distinctly hole-dwellers; hence, they are commonly met with in brackish swamps. Among the fishermen in the Batangas Province, they are known as *alimango sa butas* (crabs in holes); this habit, is in contrast to the decided propensity of the *banhawin* toward a roving life.

At first there was no plan to go into the question of taxonomy. But in the course of the study the following problems occurred:

(1) Variations in the modes of spermiogenesis.

(2) Somewhat corresponding deviations in the process of ookinesis.

(3) Differences in the form and structure of chromosomes.

These features together with the external differences discussed above as well as differences in bionomics led the writer to suspect the existence of more than one species.

MATERIALS

The crabs used in these studies were bought from the markets in Baguio, Manila, Batangas, Batangas Province, and from places around Dagatdagatan Experimental Station at Malabon in Rizal Province.

METHODS

Crabs of different sizes were dissected during different months—March, April, May, June, July, August, September,

and December. The conditions of the gonads were studied to determine the probable range of the spawning season, and the relative sizes at which these crabs attain sexual maturity.

Pieces of the testes and of the ovary obtained by cutting across the organs were fixed, using different fixatives, such as Zenker; Carnoy and Lebrun; modified Bouin with urea; modified Flemming, including Benda: chrome-aceto-osmic: Gatenby: strong Flemming without acetic acid, and Flemming's strong solution with 40 per cent formaldehyde in place of acetic acid. The best result in chromosome fixation was obtained with modified Bouin of the following formula:

Picric acid, saturated solution	parts....	75
Formaline (strong)	do.	15
Glacial acetic acid	do.	10
Urea crystals	gr.	0.5

With Gatenby's-Flemming's strong fluid without acetic acid, and iron hæmatoxylin, good results were obtained showing Golgi bodies and fat globules.

Different combinations of stains were tried. The best results were obtained with iron hæmatoxylin, acid fuchsin and anilin blue. This combination stains the chromatin black, the cytoplasm and fibers red in various shades, and the metaplasm of the secretory cells, blue.

Double embedding in collodion and paraffin was employed for pieces of ovary containing mature eggs. After dehydration the tissues were soaked in collodion dissolved in equal parts of ether and absolute alcohol for about two weeks; then passed through either cedar oil or clove oil, in the meanwhile the collodion film formed removed around the tissues. The tissues were then passed through equal parts of absolute alcohol and benzene; through pure benzene, and then benzene and soft paraffin (in solution). The tissues stayed in the last solution about a week. The tissues were then embedded in pure hard paraffin. Good sections of eggs were obtained by this method. The usual method of preliminary infiltration with soft paraffin in the oven was avoided to reduce the chances of the tissues becoming too brittle from overheating. The sections of ovary were cut 7 microns thick; those of the testes, 5 microns thick.

ACKNOWLEDGMENTS

To the late Dr. Hilario A. Roxas, formerly head of the Department of Zoology, University of the Philippines, I wish to express

my gratitude for his kindness in extending to me the facilities at the Dagatdagatan Experimental Station. Doctor Roxas was at the time the chief of the Division of Fisheries, Department of Agriculture and Commerce. I am also indebted to Dr. Deogracias Villadolid, now Director, Bureau of Fisheries, for extending to me the same privileges. My thanks are also due to Mr. Heraclio Montalban for his ready cooperation in placing at my disposal the necessary conveniences. I am also grateful to Mr. Felix Arriola and to other members of the station staff who helped me in securing the material from fishermen. And lastly, to Dr. Leopoldo S. Clemente, the present head of the Department of Zoology, University of the Philippines. I wish to take this opportunity to express my appreciation for his patience in going critically over the histological portion; and to Dr. Leopoldo B. Uichanco, dean of the College of Agriculture, University of the Philippines, and to Dr. Marcos A. Tubangui, of the Institute of Hygiene, for their valuable suggestions and criticisms.

Family PORTUNIDÆ

(Swimming Crabs)

Portunidæ MIERS, Challenger Report, Zool. **17** (1886) 169.

Carapace depressed, moderately transverse, usually widest at last antero-lateral spines. Front horizontal. Orbits and eye-stalks nearly always of moderate length. Lateral teeth usually from five to nine. Last legs usually adapted for swimming, with terminal joints ovate, flatly expanded.

Genus SCYLLA de Haan, 1833

Scylla DE HAAN, Fauna Japonica, Crust (1833) p. 11; A. MILNE-EDWARDS, Ann. Sci. Nat. Hist. Zool. (4) **14** (1860) 228, 249; Archiv. du Mus. **10** (1861) 347.

Carapace transverse, bread, moderately convex, with an almost unbroken surface. Front proper well delimited from inner supra-orbital-angles, cut into four teeth; its breadth (excluding supra-orbital angles) between a fourth and fifth of greatest breadth of carapace.

Antero-lateral borders oblique, arched, longer than postero-lateral, cut into 9 teeth of nearly equal size.

Orbits without any dorsal inclination; two nearly closed fissures in the upper wall; inner angle of lower border dentiform and prominent. Antennules folded nearly transversely. Ba-

sal antennal joint produced to form a lobule lying in the orbit; flagellum, of good length, standing in the orbital hiatus.

Epistome sufficiently long fore and aft, not sunken. Buccal cavern squarish, broader than long; efferent branchial channels cavernous, but not defined by ridges.

Chelipeds massive, longer than any of legs; arm wrist and hand with definitely placed spines; hands deep and full, not prismatic, not costate.

Legs stout, moderately compressed; in fourth pairs merus and carpus shortened and broadened, and propodite and dactylus typically foliaceous for swimming.

Abdomen of male rather broadly triangular, consisting of 5 segments, third to fifth terga being fused. First tergum much concealed beneath carapace.

SCYLLA SERRATA (Forskal). Plate 1, fig. 1

Cancer serratus FORSKAL, Descript. Anim. p. 90.

Lupea tranquebarica H. MILNE-EDWARDS, Hist. Nat. Crust. **1** (1834) 448.

Scylla tranquebarica DANA, U. S. Explor. Exped. Crust. **1** (1852) 270; STIMPSON, Acad. Nat. Sci. Philad. (1858) 38; STIMPSON, Smith Misc. Coll. **49** (1907) 75.

Scylla serrata DE HAAN, Fauna Japonica Crust. (1850) 44.

Scylla serrata DE HANN Fauna Japonica, Crust. (1860) 44; KRAUSS, Sudofr. Crust. p. 26; MIERS, Ann. Mat. Nat. Hist. **5** (1880) 238; MIERS, Chall. Rept. Brachyura **17** (1886) 185; DE MAN, Arch. fur Naturges., Jahr. **53** (1888) 332; CHIA-JUI SHEN, The Crabs of Hongkong. The Hongkong Naturalist **3**, No. 1 (1932) 32.

Carapace about two-thirds, or a little less, as long as broad, practically smooth, except for a faint granular ridge running obliquely inwards across either branchial region from last spine of antero-lateral border.

Front cut into four lobes or bluntish teeth of about equal size and prominence. Antero-lateral border cut into nine sharply acuminate teeth of about equal size. Posterior border forming a curve with postero-lateral borders, points of junction sometimes slightly thickened.

Merus of external maxillipeds oblique but not having antero-external angle distinctly produced in a lateral direction.

Chelipeds not quite twice length of carapace in adult male, but shorter than in female and young male. Arm with three spines on anterior border, and two on posterior border one terminal, other submedian; a strong spine at inner angle of wrist, outer angle being rounded and armed with one, or sometimes,

two spines or teeth. Hand with three spines or tubercles, one being in front of apex of wrist joint, other two being side by side behind finger-joint, outer of these two sometimes obsolescent.

Legs unarmed: dactyli strongly sulcated, their anterior and posterior margins fringed with brushlike hairs.

Abdomen of male broadly triangular: oval in young families, but becomes more circular in outline in big females.

Remarks.—Carcinologists have hitherto recognized only one local species under this genus. Miers (1886) recognized only *S. serrata;* and Stimpson (1907) seems to be of the opinion that *S. serrata* and *S. tranquebarica* are synonyms. Both Dana (1852) and Stimpson placed *S. oceanica* as a variety under *S. tranquebarica.* The present study attempts to establish three species and one new variety.

De Haan, in adopting *Scylla* for the generic name, must have had in mind the habitat and habits of the crabs. *Scylla* (Lat. from Gr. *Skylia*) is described in Greek mythology as a sea monster, dwelling in a cave in a precipitous cliff that guarded the entrance to a passage. She is said to devour any prey that comes within her reach. This allusion does not fit the *banhawin* (*bulik*) crabs, because they do not live inside the holes. The allusion fits *S. serrata.* Kraus (in Sudafr. Crust.) relates: "this species lives in great deep holes, and wears the dingy earthy color of its residence. They sit at the opening of their holes when the tide is coming in, to snap at the food which it brings them."

In *Scylla serrata* the outer of the two spines behind the fingerjoint is described as obsolescent (Plate 1, fig. 1b. This is so in the true *mamosain,* where in some cases especially in big males, the spine is reduced to a mere inconspicuous vestige. Among the *banhawin* group both spines are conspicuous; the outer one, however, is generally smaller.

Between the true *banhawin* and the true *mamosain,* there are two groups of individuals that seemingly occupy the intermediate positions in general coloration, one group closely approximating the *banhawin,* while the other resembling closely the *mamosain.* On the whole the differences in the shades of color and in the extent of pigmented areas can be passed on easily as simple variations that can be attributed to such factors as age and environment. But when these disimilarities are supplemented by (*a*) differences in form and size of the chromosomes, and (*b*) differences in the process of

spermiogenesis and ookinesis, they then assume greater significance. Obviously, they are due to fundamentally deep-seated factors inherent in the distinctive make-up of the individuals. To serve as bases for description and for convenience, the group that closely resembles the true *banhawin* is designated as *parabanhawin* and those that closely approximate the true *mamosain* (*S. serrata*), as *paramamosain*. The true *banhawin* is identified in this paper as *S. oceanica*, and the *parabanhawin* as *S. tranquebarica*, the *paramamosain* is regarded as a variety under *S. serrata*.

SCYLLA OCEANICA (Dana) Banhawin. Plate 1, fig. 2.

Scylla tranquegarica var. *oceanica* DANA, U. S. Explor. Exped. Crust. 1 (1852) STIMPSON, Smith. Misc. Collection 49 (1907) 75.

Diagnosis.—This species can be distinguished from *S. serrata* by the following characteristics:

1. The general coloration is predominantly greenish, the shades in some places of the body becoming grayish green in bigger specimens. The carapace, legs, and abdomen are ornamented by large pigmented areas of whitish gray bordered by purplish dark-brown lines. These ornamental markings are absent in *S. serrata* in which only irregularly disposed small whitish spots may be seen on the carapace and on the last legs, and the general coloration is usually deep ferrugineous brown; the shades of color may sometimes vary, assuming a light purplish brown.

2. *S. oceanica* ordinarily grows bigger. It is not unusual to see specimens that measure about nine inches across the widest portion of the carapace. Probably bigger specimens may exist.

3. Brushlike setæ (Plate 2, fig. 2) are present quite abundantly over the carapace of *S. oceanica*. While in *S. serrata* the setæ appear to be shorter and are apparently confined only to the hepatic region just below the orbit.

4. They differ in habitat: *S. serrata* referred to in this paper as the *mamosain*, usually lives in holes; while *S. oceanica* (the *banhawin*) seemingly prefers a nomadic life, and is commonly caught in open seas.

5. Relatively, more pores perforate the carapace of *S. serrata*. The hypodermal papillary tubes (Plate 2, fig. 3) protrude through these pores. These minute tubes are extensions of the hypodermis and are, obviously, respiratory in function. (See section in bionomics.)

Other differences as revealed by cytology:

6. Their chromosomes differ in their physical make-up and in form.

7. The modes of spermiogenesis and ookinesis also differ. These and other cytological differences will be brought out more in detail in the course of the discussion.

Remarks.—Both Dana (1852) and Stimpson (1907) consider *S. oceanica* as a variety under *S. tranquebarica.* Stimpson pointed out the existence of two sufficiently distinct varieties. He gave as the distinguishing characteristics of *S. oceanica* the following: (1) the frontal teeth are blunt, with the median incision deepest; (2) the posterior teeth of the anterolateral margin is longer than in the other. Stimpson described the coloration in the species as follows: "carapax olive green above, white below; hands often reddish and spotted with green exteriorly; fingers always red, feet pale greenish, with dark spots below."

H. Milne-Edwards (1834) characterized *Lupea tranquebarica* as the biggest species of *Portunidæ,* and, according to him, they may attain the length of from six to eight inches; the color is grayish green, and they inhabit the Asiatic seas. Presumably his specimen was *S. oceanica,* since this is the variety that grows very big, and the big ones are, apparently, sea-dwellers.

Notwithstanding their close similarity with regards to general coloration, the writer proposes to raise *S. oceanica* to the category of a distinct species and to include therein forms which are:

(1) Predominantly greenish or grayish green on carapace and legs, including chelipeds; these parts ornamented by large pigmented areas.

(2) Those lengths of chelipeds (in male) not more than twice the length of carapace; hands not reddish or purplish as a whole, though splashes of reddish color may appear.

If the writer were to consider one as a variety under the other, he would choose *S. tranquebarica,* on the ground that the general coloration and color markings on this group seem to be more variable; and on the basis that the germ cells of *S. tranquebarica* are heterogametic, they exhibit sexual digamety and dimegaly. While those of *S. oceanica* are apparently homogametic, a condition which implies more stability of character.

SCYLLA TRANQUEBARICA (Fabricius) Dana. (Parabanhawin). Plate 3, fig. 1.

Pertunus serratus RUPPEL, Krabben die rothen Meeres, p. 19, *pl. 2, fig. 1.*

Lupea tranquebarica MILNE-EDWARDS, Hist. Nat. Des Crust. 1 (1834) 448.

Scylla serrata DE HAAN, Fauna Japonica, Crust. (1850) 44; KRAUSS, Sudafr. Crust., p. 25.

Scylla tranquebarica DANA, U. S. Explor. Exped. Crust. 1 (1852) 270, *pl. XVI, fig. 6;* STIMPSON, Acad. Nat. Sci. Philad. (1858) 38; STIMPSON, Smith. Misc. Collection *49* (1907) 75.

Diagnosis.—Differs from *S. oceanica* by the following characters:

1. General coloration varying from deep purplish drab-green to lighter in shade; overall greenish background which is characteristic of the true *banhawin* (*S. oceanica*) generally showing only on the carapace and on some portions of the legs.

2. Large pigmented areas generally distinct only on the last legs; indistinct on the other legs and on abdomen of female. Chelipeds usually purplish; fingers red, often tipped with white.

3. Relative differences in the size of the chelipeds more apparent, especially so in males, where the chelipeds are enormously big in relation to the body. In adult males the length of the chelipeds is more than twice that of the body.

4. As in *S. oceanica,* the nurse cells in the gonads are distinctly vacuolated; in size the auxocytes compare favorably with those of the aforementioned.

5. Unlike those of *S. oceanica,* however, the sperms of *S. tranquebarica* exhibit sexual digamity and the ova show sexual dimegaly.

Remarks.—The variations in general coloration and in color markings within the species are quite diverse; it is difficult to determine whether they should be regarded as simple external variations, or something that preclude existence of races or varieties. These need further cytological studies.

According to Stimpson, these species are found on the shores of the continent of Asia, chiefly in muddy estuaries. They are sold in great numbers in the markets of Hongkong and Canton.

In the Philippines the market supply of these crabs generally comes from the fishponds; considerable quantities of the crabs are also caught from the muddy shores of bays, coves, and chiefly the muddy estuaries.

SCYLLA SERRATA var. Paramamosain var. nov. Plate 3, fig. 2.

Characters.—The general configuration of the body is very similar to that of the typical species. In both the body is relatively thicker, appears to be more compact, and the carapace looks more convex than that of either *S. oceanica* or *S. tranquebarica.* The H-like mark on the carapace is relatively faint; the figure is deeply impressed in both *S. oceanica* and *S. tranquebarica.*

Variety *paramamosain* differs from the typical species by the following characters:

1. Median pair of frontal lobes slightly more anteriorly produced than the two laterals.

2. Outer of the two spines at the base of the fingers, though smaller than the inner, neither obsolescent nor dentiform; it is quite prominent. In the species, especially in big males, the outer spine becomes vestigial.

Some cytological differences

3. The ova of *paramosain* exhibit sexual dimegaly. The condition in the sperm has not been determined.

4. The form and the apparent physical constitution of the chromosomes of *paramamosain* differ from those of the *mamosain* (*S. sererata*).

5. The modes of spermiogenesis and ookinesis also differ in these two groups.

Color.—It is rather hard to distinguish offhand the variety from the typical species in so far as general coloration is concerned. There is an apparent tendency in the variety, however, to assume a lighter shade of color, which is usually brownish with splashes of gray. Usually, there are patches of bluish green at the angles of the joints of the legs and chelipeds. The spines in the chelipeds are of this color excepting the tips. Small pigmented areas, but rather irregularly disposed, may be seen on the last legs; these areas consist of groups of whitish spots, and as in the species, they are not bordered by distinct lines.

On the whole the shades in color and the color markings may vary with such factors as age or environment. Also, there are no distinctive external differences. Hence, despite differences in the physical constitution of their chromosomes and in the modes of spermiogenesis and ookinesis, it seems safer with the present state of our knowledge tentatively to place *paramamosain* as a variety.

Key to the Philippine Scylla.

a 1. General ground color greenish, grayish green or olive-green; sometimes with shades of purplish or reddish generally on chelipeds and legs. Contour of body not very distinctly convex; H-like mark on carapace relatively deep.

b 1. Carapace and legs, including chelipeds, predominantly greenish or grayish green; large polygonal pigmented areas present on all legs, including chelipeds, and on abdomen in females; chelipeds in adult males not more than twice length of carapace—*S. oceanica.*

b 2. Carapace olive-green, purplish with greenish tint, or purplish brown; large polygonal pigmented areas distinct only on last legs, and a few may be seen on the abdomen in females; chelipeds often reddish or purplish, length in adult males more than twice length of carapace ..... *S. tranquebarica.*

a 2. General ground color deep rusty-brown, purplish brown to light brownish gray; dorsal contour of body more distinctly convex; H-like figure on carapace relatively less deep.

b 1. Color varying from deep rusty brown to the purplish brown; outer spine on base of fingers obsolescent, becoming vestigial on bigger specimens; frontal teeth about same level..... *S. serrata.*

b 2. Color generally brownish gray with patches of bluish green at joints of legs and chelipeds; median pair of frontal teeth slightly produced anteriorly; outer spine on base of fingers unequal but not obsolescent ..... S. *serrata* var. *paramamosain* var. nov.

Dimorphism.—Usually the right cheliped is bigger than the left, but in cases which are apparently not very uncommon, the left is bigger than the right. The difference in size between the chelipeds is more pronounced in males than in females, and is quite exaggerated among the *paramamosain,* but more so in *S. tranquebarica* (*parabanhawin*). In these groups, especially in males of *tranquebarica,* the chelipeds appear to be enormously big in relation to the size of the body. The hand is thickly inflated and smooth; the fingers are very large, thick, and strong, curved and furnished with large thick teeth. In males the circumference of the hand measured at the base of the fingers almost equals the width of the carapace.

Changes in the form of the abdomen as the crab approaches maturity.—There are individuals with abdomen oval, instead of triangular, and considerably broader than the abdomen in males, but not broad enough to compare with that of a mature female (Plate 2, figs. a, b, and c). These are immature females; their sternal concavity is deep as in males, and the vulva is rather reduced in size. The abdominal appendages are also relatively reduced in size. Studies made on the stained sections of the gonads of two crabs—one, a *mamosain,* and the other a *banhawin*—revealed the presence of

oöcytes and immature ova in different stages of development. In the individuals studied, there were no indications of the presence of developing male germs, so that apparently no copulation had previously taken place. As the crab grows older, the abdomen increases in width, and becomes more or less rounded.

As stated previously, the present study was started with the presumption that there is only one species. Hence, in the earlier part of the investigation, no attempt was made to classify the crabs. The discovery of existing differences, which obviously point to the existence of more than one species, made it necessary to change the methods. A systematic checking of the results thus far obtained is also made imperative. Some of the materials that were used in this checking are included in the Table 1 to show the degree of dimorphism as shown in the difference of the size of the chelipeds; and also, to show the difference in the general coloration and color markings.

TABLE 1.—*Showing some of the characteristic features of the Philippine species of the genus Scylla.*

Species	Measurements of carapace		Circumference of palm [a]		General coloration and color markings
	Width	Length	Right	Left	
	cm.	*cm.*	*cm.*	*cm.*	
S. oceanica (banhawin):					
Female	11	8	9	7.4	Greenish with large pigmented areas on carapace, legs and abdomen.
Do	11	8	8	7	Do.
Do	12	8.2	7	9	Do.
Male	12	8.2	7.5	9.1	Do.
Female	19.5	13.6	13	11.5	Carapace drab-green due to algal growth.
S. tranquebarica (parabanhawin):					
Male	12.8	8.7	12.7	[b]	Light brownish purple; big pigmented areas on last legs only. Crab still soft.
Do	14.2	9.6	13.7	12.4	Carapace greenish; chelipeds purplish, large pigmented areas on last legs only. Circumference of chelipeds almost the same as width of body.
S. serrata (mamosain):					
Male	10.5	8	8.5	7.2	Deep rusty brown; scattered whitish spots on last legs.
Immature female	7.3	5.3	4.8	3.5	Deep purplish brown; whitish spots on last legs.
Do	6	4	3.8	3.2	Do.
S. serrata var. *paramosain:*					
Female	9	6.5	6	5.3	Light purplish brown; with splashes of bluish green on joints of legs and chelipeds, whitish spots on last legs.
Male	10	7.2	9	8	Same color marking as foregoing.
Female	11.7	8.2	7.2	6.4	Dark purplish brown; with splashes of ferrugineous areas on other parts of body.

[a] Measurements were taken at the base of fingers.

[b] Missing.

GENERAL DISCUSSION

The separation of *S. oceanica* from *S. tranquebarica* as distinct species is amply justifiable. The external differences of these species supported by other characteristic features indicated by variations in the modes of spermiogenesis and of oökinesis; and by the peculiarities in the form and physical constitution of their chromosomes, etc.—these are quite sufficient bases.

Aside from their ecological preferences, the *banhawin* (*S. oceanica*) are distinctly different from the *mamosain* (*S. serrata*) in their external features. The presence of large polygonal pigmented areas that mark the carapace, all of the legs including the chelipeds and abdomen in females, make the former group easily recognizable from the latter. In *mamosain* only whitish spots may be seen here and there, on the carapace and on the legs, but on closer examination these spots appear to be groups of pigmented dots, and they are not delineated by distinct boundary lines. There is no possibility of mistaking a *mamosain* from a *banhawin.*

Because of their close similarity in general external appearance and in coloration, the writer tentatively places *paramamosain* as a variety under *S. serrata,* notwithstanding their cytological differences.

Undoubtedly, the study on the genetics of these groups will prove very interesting. Experimental breeding will furnish evidences from fertility-sterility test held by many as an objective method of demonstrating species validity. On the whole, capacity to interbreed with fertile offspring is regarded as a very significant evidence in any consideration of the degree of consanguinity of closely similar stocks.

The segmented character exhibited by the chromosomes, and in some cases the tendency of chromosome-constituents towards the formation of a somewhat loosely arranged groups, are altogether significant. Those arrangements of chromosomal components make possible the so-called "translocation", or "displacement," in which a piece of chromosome becomes transversely detached and joins the chromosome of another pair. This segmental interchange gives rise to a new linkage group, since the genes contained in the translocated section are now free from the genes with which they were previously associated; they may become a part of another linkage group constituted by the chromosome to which they have become

attached. This had been observed in many animals; it may have been taking place in these crabs too—a possibility which is hinted by the physical constitution of the chromosome.

Translocation, or displacement, is regarded as having a great influence in the evolution of new species, since it provides a rapid means of chromosome differentiation which must have a great influence on the evolution of new races, varieties, subspecies, and species.

From observations embracing differences in general coloration, color markings, and other external features, the writer suspects that besides the ones discussed in this paper, there are at least other variations.

The existence of *mamosain* (*S. serrata*) in considerable number in certain regions in the Philippines appears to be correlated with the existence of extensive mangrove swamps. The relation is obvious, on the ground that these crabs are distinctly fossorial mud-dwellers. The mangrove with its stiltlike roots and a variety of other plants with similar growth habits, especially *Senneratia pagatpat* Blanco, *S. caseolaris* (L.) Engl., and *Aegiceras corniculatum* (L.) Blanco, are common on the quiet coastal areas. The tangle of roots holds debris that were brought down by rains and that drifted with the tides until it decays. In and upon the mud is found a remarkable assemblage of marine, freshwater, and terrestrial animals. A habitat with such conditions gives ample protection to the crabs, and wonderfully fit their predaceous and scavenger habits.

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ILLUSTRATIONS

PLATE 1

FIG. 1. (*a*). *Scylla serrata* (Forskål); female.

(*b*). *Scylla serrata* (Forskål); left cheliped of male showing the spines behind the finger joint; the outer has become vestigial.

2. *Scylla oceanica* (Dana); female.

PLATE 2

FIG. 1. (*a*). Abdomen of a female *S. oceanica;* width of carapace 19.5 cm.; length, 13.6 cm.

(*b*). Abdomen of young female *S. oceanica:* width of carapace 11.6 cm.; length, 8.2 cm.

(*c*). Abdomen of a female *S. serrata* var. *paramamosain:* width of carapace 11.6 cm.; length, 8.3 cm.

2. Terminal portion of a brushlike seta from the carapace of *S. oceanica* (*banhawin*); × 1350.

3. A hypodermal papillary tube taken from the carapace of the same specimen; × 1350.

PLATE 3

FIG. 1. *Scylla tranquebarica* (Fabr.) Dana; male.

2. *Scylla serrata* var. *paramamosain* var. nov.; female. (Note the two spines behind the finger joints, which are almost equally prominent.)

1

2

PLATE 1.

1

2

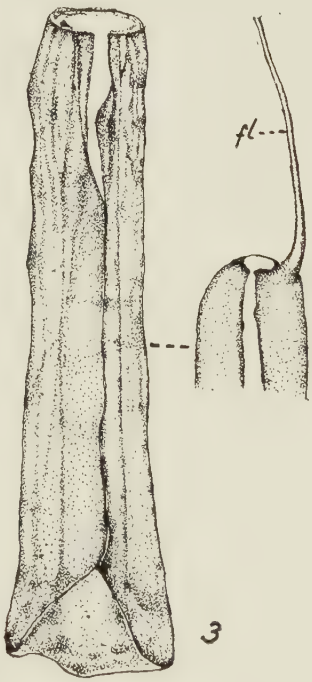

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PLATE 2.

1

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PLATE 3.

ANALYSIS AND COMPOSITION OF MANILA ELEMI

By Gloria D. Manalo and Augustus P. West [1]

Manila elemi is one of the well-known minor forest products of the Philippines. It is a resin that is contained in the bark of the pili tree, *Canarium luzonicum* (Blume) A. Gray, and oozes out when the bark is cut.

It is used in pharmacy as an ingredient in plasters and ointments. It is employed in making paints, varnishes, lacquers, and also as a constituent in the manufacture of plastics and printing inks. Locally it has served as varnish and as material for caulking boats. Forest dwellers roll the resin in leaves and use it as an illuminant. A large torch, thus prepared, gives a light that burns for many hours and can be seen far away.

For many years Manila elemi has been exported from the Philippines but the quantity shipped annually has varied considerably. In 1940 the amount sent abroad was valued at ₱90,264.[2]

By operating a pilot plant for the manufacture of commercial products from Philippine resins, like Manila elemi and copal, very likely important new industries could be developed.

Resin obtained from different locations usually contains more or less foreign matter (leaves, twigs, etc.) and varies in composition. For industrial purposes it is desirable to ascertain the quality of Manila elemi and also the amount of individual resin constituents. We have devised an accurate and convenient method of analysis and the details are given in this paper. There are also included the data on some characteristic samples of Manila elemi, as determined by this procedure.

Clover [3] and also Bacon [4] have carried out extensive researches on Manila elemi collected in the Philippines. Their investigations were confined particularly to the volatile oil obtained from this resin. A review of their work [5] is given in Bulletin 20 of the Philippine Bureau of Forestry.

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[1] Formerly of the Bureau of Science, now Institute of Science.

[2] Annual Report. Insular Collector of Customs, Manila. (1940) One peso equals 50 cents United States currency.

[3] Philip. Jour. Sci. **2** A (1907) 1.

[4] Philip. Jour. Sci. **4** A (1909) 93.

[5] West, A. P., and W. H. Brown. Philip. Bur. For. Bull. **20** (1920) 40.

The name elemi is a term that is applied to a variety of resinous products obtained from different countries and having different botanical origins. In the Philippines only one elemi resin is collected and this is obtained from *Canarium luzonicum* which grows abundantly at low and medium altitudes in the primary forests of Luzon, Mindoro, Ticao and Masbate. It is the only Philippine tree that gives this resin in sufficient quantities for profitable collection.

In addition to *Canarium luzonicum* there are various other species of *Canarium* in the Philippines. *Canarium ovatum* grows abundantly in southern Luzon. It produces nuts known as pili nuts and is said to give an annual yield of about 33 kilos. These, when roasted, are very tasty and nutritious. They are used in making confections and, by many, are considered superior to almonds.

The oil [6] from pili nuts has good keeping qualities, and a composition similar to peanut oil.

On account of the popularity of pili nuts the tree, *Canarium ovatum,* is called the pili-nut tree. The name "pili" is also applied locally to other *Canarium* species such as *C. luzonicum.* The latter also yields edible pili nuts but they are much smaller than those obtained from *Canarium ovatum.*

Manila elemi is also known by the Spanish name, "brea blanca" (white pitch). When the resin first exudes from the tree it is always soft and oily and has a very fragrant odor. On standing, however, it gradually loses volatile constituents and hardens.

Forest ranger Rabaya [7] investigated the elemi industry in the province of Tayabas. Concerning *Canarium luzonicum* and elemi resin he states:

> Pili tree is deciduous. It changes its leaves once a year during the dry season. At the beginning of the dry season (in the month of February in the Province of Tayabas), some trees begin to shed their leaves. The falling of the leaves becomes general as the dry season advances, so that in the latter part of March and April most trees are leafless or nearly so. Early in May, young leaves begin to grow and their purplish red color renders the trees conspicuous for miles. ... It appears to thrive best in Southeastern Luzon, where there are no distinct dry and wet seasons. It is also grown in the Islands of Masbate and Samar. In the Province of Tayabas alone, it is estimated that there are close to 25,000 pili trees available for resin tapping.

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[6] West, A. P. and S. Balce. Philip. Jour. Sci. **23** (1923) 29.

[7] Bureau of Forestry Report not published.

Tapping begins in the early part of July, or as soon as the new leaves become green and mature, and continues until March when the trees shed their leaves. The length of the tapping season is, therefore, a little over 8 months.

A young tree of 15 centimeters in diameter (B. H.) yields an average of 2 kilos of resin per month or 16 kilos per season, a 60 centimeter tree yields 60 kilos, while a tree 1 meter in diameter, 120 kilos or more. It is claimed that pili trees growing along the gulleys produce more resin.

The greater bulk of the resin exported to foreign markets comes from Tayabas Province, principally from the towns of Gumaca, Calauag and Lopez. During the year 1925, a little less than 100,000 kilos of resin were collected in Tayabas Province alone, and if prices warrant extensive collection, it is believed that as much as 300,000 kilos can easily be produced in one season.

In Masbate,[8] according to Forester Zschokke, the trees are tapped at the beginning of the rainy season and the process is repeated every other day until December. The resin is collected once a month and one man can take care of 75 to 100 trees. The trees must be visited regularly to get good returns. The resin can be gathered at almost all seasons, but towards the end of the dry season the flow is very slight. Collections are made from the same trees year after year.

Clover says that he has seen large-sized trees on which at least ten pounds of the exudation had accumulated probably within a month. Bacon estimates that a mature tree will yield an average of 45 kilos per year. He says that he has seen as much as 32 kilos on a large tree. This amount represented a two months flow.

The volatile portion of the resin is called elemi oil and is usually obtained by steam-distillation. Clover collected samples of elemi from a number of trees. These were distilled and the optical rotation, specific gravity, and refractive index of these distillates determined. The results varied considerably. Clover concluded that this variation was due to a difference in the resin obtained from individual trees. He isolated various terpenes from his numerous samples. According to his investigations:

The combined results obtained by a careful examination of the oils from 21 individual samples of resin establish the true composition of elemi oil so far as these samples may be considered as representative of the aggregate product. In several cases, notably in the last sample examined, substances were obtained which were not encountered in any other; it seems possible, therefore, that were the investigation continued, still others

[8] West, A. P. and W. H. Brown. Philip. Bur. For. Bull. *20* (1920) 42.

would be found in which new constituents would appear, although such cases would be rare and the substances themselves would constitute so small a proportion of the aggregate oil that they would scarcely need to be taken into account.

It is obvious that in considering Manila elemi or the oil obtained therefrom as products of a species, we must deal with an aggregate sample of these products; a sample derived from so great a number of individual trees that the peculiarities of the individuals disappear. If the native gatherer of resin utilizes a large number of trees and regularly removes the resin from them in small portions, the product which he places upon the market will be nearly homogeneous and a representative sample; but if he obtains his resin from a limited number of individuals his product will not be representative and, if he utilizes resin which has accumulated upon the trees in large quantity, it will not be homogeneous.

Granted that we have a representative sample of resin, the composition of the oil will also be influenced by the following factors:

(1) The age of the resin.

(2) The temperature of the distillation. This factor will largely determine the proportion of the high-boiling part of the oil and will influence the composition of the terpene portion, because some of the terpenes suffer a change at higher temperatures.

(3) The length of time used in the distillation. This factor will influence only the proportion of high-boiling oil.

Yield of oil.—In the first seven samples examined considerable difference was found in the oil content. While there may be a certain amount of variation shown by the individual samples in this respect, it is thought that the differences found are more directly connected with the age of the resin. As previously noted, Schimmel & Co. state that the yield of oil is from 15 to 30 per cent. In several cases where I have examined samples of fresh, soft, resin purchased in Manila, I have always found that total yield to be from 25 to 30 per cent of the weight of the resin.

Bacon investigated the volatile oil separated from numerous specimens of elemi resin obtained from individual trees. His experiments verified the conclusions of Clover that elemi terpene oils vary a great deal in their boiling points and optical rotation.

By the distillation of elemi in vacuo, Bacon obtained from 12 to 18 per cent of terpenes and from 12 to 15 per cent of a higher-boiling oil. The distillation residue, usually amounting to about 70 per cent of the elemi, is a light-brown, transparent, solid resin, with a brilliant fracture. It is completely and easily soluble in the cold in the following solvents: alcohol, ether, benzol, petroleum ether, ligroin, xylol, chloroform, amyl acetate, acetone, methyl alcohol, carbon tetrachloride, ehtyl acetate, turpentine, amyl alcohol, and glacial acetic

acid. Bacon thought this product has commercial possibilities as a varnish gum. He subjected it to destructive distillation. He says:

> One kilo of this residue was distilled in a 2-liter Jena flask. It melts quietly with very little darkening and no foaming, evolution of gas, or other signs of decomposition. As the temperature is increased, considerable cracking and evolution of water soon takes place and the whole mass becomes very dark, the oil beginning to distill at a vapor temperature of 200° C. The whole distillation is very quiet with no foaming or frothing and very little evolution of gas. The oil at first is green, then an intense, flourescent blue and toward the close of the distillation almost white. The total distillate was 670 cubic centimeters of which 40 were the aqueous layer. Three hundred and ten grams of black tar were left in the distilling flask. The oil, shaken out with dilute alkalies, gave 18 grams of acids, while after saponification with alcoholic potash a further 7 gram of acids were obtained. The neutral oils distilled in vacuo gave fractions at 10 millimeters of about 90 grams each . . .
>
> There were no indications of any separable, individual products, and nitration and oxidation of these fractions under various conditions gave no promise of obtaining individual compounds. This oil obtained by the destructive distillation of elemi is evidently a resin oil of the same general character and useful for the same purposes as other resin oils.

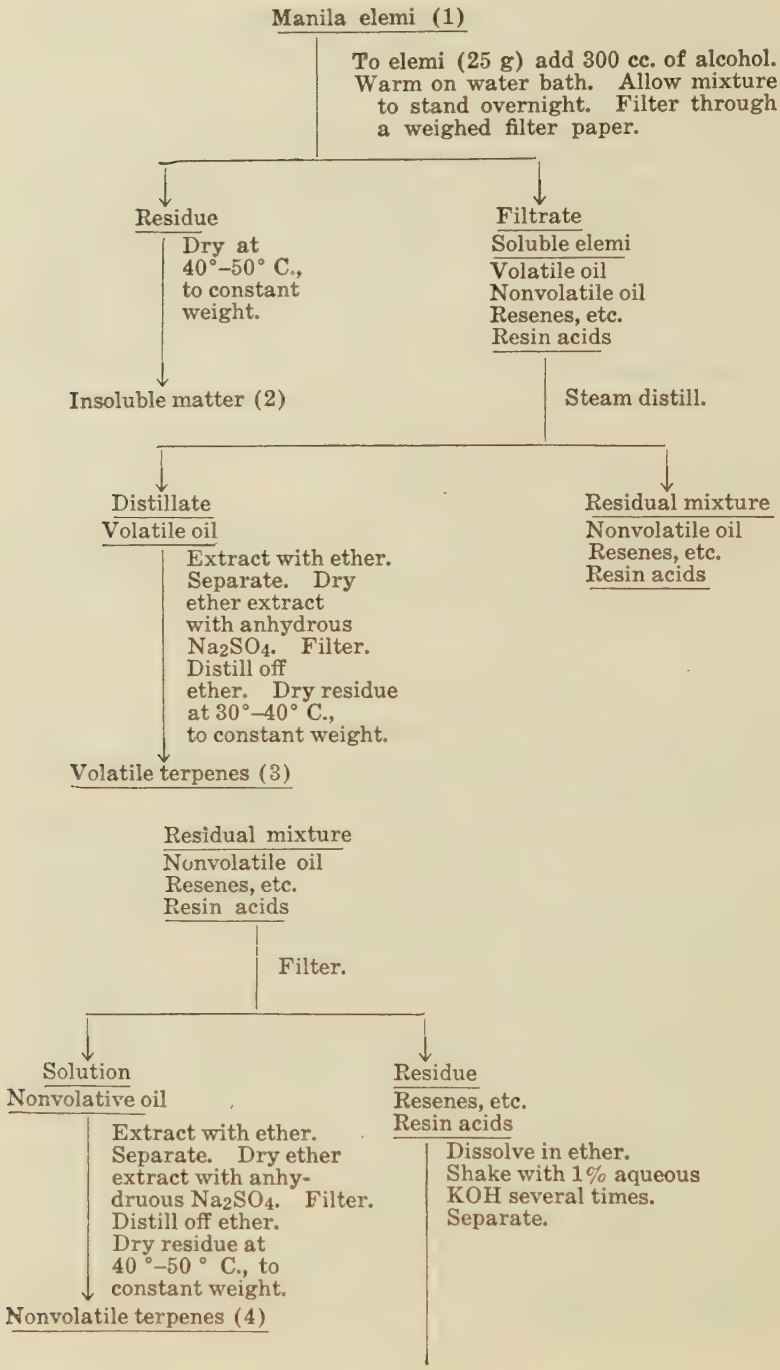
EXPERIMENTAL PROCEDURE

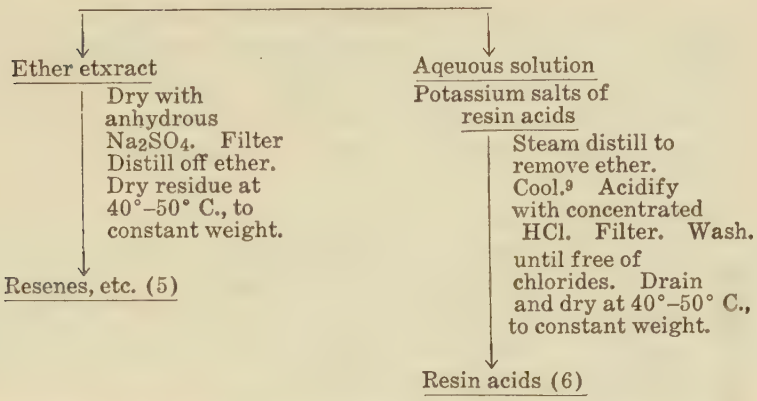
The samples of Manila elemi used in this investigation were obtained from F. E. Zuellig Company (resin dealers), Manila. The resin was collected in Tayabas province.

Acid number.—The acid number was ascertained by treating approximately 1 gram of elemi resin with 50 cc. of a mixture consisting of neutral absolute alcohol and benzene (25 cc. each) and titrating directly with tenth-normal alcoholic potassium hydroxide using phenolphthalein as indicator.

Saponification number.—For this determination approximately 1 gram of elemi resin was treated with 50 cc. of absolute alcohol after which 25 cc. of tenth-normal alcoholic potassium hydroxide were added. The mixture was heated on a stream bath with a reflux condenser for 2 hours. The solution was then cooled and the excess alkali titrated with tenth-normal sulphuric acid in the presence of phenolphthalein.

Manila elemi analysis.—Preliminary experiments were carried out to ascertain a convenient method for separating the constituents of Manila elemi. The procedure outlined below gave satisfactory results.


Manila elemi (1)
To elemi (25 g) add 300 cc. of alcohol. Warm on water bath. Allow mixture to stand overnight. Filter through a weighed filter paper.
Residue
Dry at 40°–50° C., to constant weight.
Insoluble matter (2)
Filtrate
Soluble elemi
Volatile oil
Nonvolatile oil
Resenes, etc.
Resin acids
Steam distill.
Distillate
Volatile oil
Extract with ether. Separate. Dry ether extract with anhydrous Na_2SO_4. Filter. Distill off ether. Dry residue at 30°–40° C., to constant weight.
Volatile terpenes (3)
Residual mixture
Nonvolatile oil
Resenes, etc.
Resin acids
Residual mixture
Nonvolatile oil
Resenes, etc.
Resin acids
Filter.
Solution
Nonvolative oil
Extract with ether. Separate. Dry ether extract with anhydruous Na_2SO_4. Filter. Distill off ether. Dry residue at 40 °–50 ° C., to constant weight.
Nonvolatile terpenes (4)
Residue
Resenes, etc.
Resin acids
Dissolve in ether. Shake with 1% aqueous KOH several times. Separate.


Ether etxract
Dry with anhydrous Na_2SO_4. Filter Distill off ether. Dry residue at 40°–50° C., to constant weight.
Resenes, etc. (5)
Aqeuous solution
Potassium salts of resin acids
Steam distill to remove ether. Cool.[9] Acidify with concentrated HCl. Filter. Wash. until free of chlorides. Drain and dry at 40°–50° C., to constant weight.
Resin acids (6)

[9] If a precipitate separates out at this stage proceed according to the following remarks on this outline of analysis.

Insoluble matter.—Manila elemi (25 g) is treated with 300 cc. of alcohol (95 per cent). The mixture of elemi and alcohol is heated on a steam bath and shaken occasionally for about a half hour. It is then allowed to stand overnight to facilitate subsequent filtration. The insoluble matter consisting of foreign material settles out on standing leaving a fairly clear supernatant liquid. The mixture is filtered through a weighed filter paper. The insoluble matter is washed with alcohol and the filtered washings are added to the soluble elemi solution. The filter paper with the insoluble matter is allowed to drain on layers of filter paper after which it is dried in an oven at from 40° to 50°C., until the weight becomes constant.

Soluble elemi.—The alcoholic solution of elemi is steam distilled to remove the terpenes. This process usually requires about 20 hours to get most of the volatile terpenes. The small portion that steam distills with difficulty can be included in the nonvolatile terpenes that are subsequently obtained.

The distillate (in portions of about 100 cc) is extracted with ether until it no longer has a milky appearance. Generally one extraction for each portion is sufficient. The combined ether extracts are dried with anhydrous sodium sulfate. The clear solution is filtered into a weighed flask and the ether distilled off. In order to eliminate the last traces of ether the flask is placed in an oven and heated for about 3 hours at a temperature of from 30° to 40°C., or until the weight becomes constant. The residue consists of the terpenes (3).

The residual mixture from the steam distillation is filtered to remove the solid residue. The filtrate, containing some nonvolatile oil, is treated in the same manner as the volatile oil except that the last traces of ether are removed by heating at a temperature of from 40° to 50°C. The residue is the nonvolatile terpenes (4).

The solid residue is dissovled in ether and shaken several times with aqueous potassium hydroxide (1 per cent). The ether extract is separated from the aqueous solution and manipulated like the ethereal extract containing the nonvolatile terpenes (4). The final product contains resenes (5) and related substances (amyrins, etc.).

The aqueous solution from the ether extract is steam distilled to remove ether and cooled to room temperature. A small amount of a white precipitate may sometimes appear at this stage as the separation of resenes and potassium salts of resin acids may not be complete. Ether is somewhat soluble in water and a small amount of resene constituents in the ether may remain with the aqueous solution of potassium salts. If a white precipitate forms it should be removed by filtering through a weighed filter paper. It is then dried to constant weight at from 40° to 50°C. This weight is added to that of the resenes (5).

By acidifying the aqueous solution of the potassium salts with concentrated hydrochloric acid the amorphous resin acids are precipitated. These are filtered through a weighed filter paper and washed with water until they are free of chlorides. The filter containing the acids is allowed to drain thoroughly after which it is dried in an oven at from 40° to 50°C., until the weight of the resin acids (6) becomes constant.

Water in Manila elemi.—This resin usually contains a small amount of water, less than 5 per cent. The presence of water can be proved by adding to an interior portion of the resin some powdered anhydrous copper sulfate which immediately turns blue. Water is conveniently determined by difference, that is, the difference between 100 per cent and the sum of the percentages of all the other constituents contained in the elemi.

Elemi constituents.—The data (Table 1) show that high-grade Manila elemi, containing only a small amount of insoluble matter, consists principally of resenes together with some resin acids and volatile terpenes. It also contains a very small amount of nonvolatile terpenes. The resenes are not acted upon by alkalies and other common chemical reagents. This

characteristic is said to enhance the value of resene resins for the manufacture of varnishes.

TABLE I.—*Composition of Manila elemi.*

Constituent	Sample		
	1	2	3
	Per cent	*Per cent*	*Per cent*
Insoluble matter	1.00	0.35	0.57
Terpenes:			
Volatile	17.40	25.21	20.01
Nonvolatile	2.08	1.07	1.22
Resenes, etc.	61.44	55.50	58.95
Resin acids	15.33	16.02	18.00
Moisture (by difference)	2.75	1.85	1.25
Total	100.00	100.00	100.00

All three samples had the same general constituents but the percentage of any particular one varied somewhat in the different samples. Specimens of elemi from the same tree may not have the same composition due to ageing and weathering. Resin that has been clinging to a pili (elemi) tree for some time and has become rather hard and weathered will naturally have a composition somewhat different from soft resin very recently exuded from the tree.

The important constants of one of these samples (Table 1) are given below:

Sample No. 2:

Saponification No.	28.53
Acid No.	18.50
Ester No.	10.03

Here again these data show that Manila elemi contains only a comparatively small amount of free resin acids and saponifiable matter.

M. Mladenovic [10] analyzed a sample of Manila elemi by a method quite different from the one we used and obtained 24 per cent of volatile oil, about 15 per cent of resin acids and about 60 per cent of resenes and related substances. These results are similar to the data given in Table 1.

In accordance with the procedure in the text, the resin acids (6), were prepared from elemi resin (sample No. 3, Table 1). These acids gave the following constants:

Saponification	125.00
Acid No.	108.47
Ester No.	16.53

[10] Bull. Soc. Chim. Roy. Yougoslav. *8* (1937) 175.

As shown by the data this product consists of a mixture of free acids and a saponifiable substance.

During recent years considerable research has been done on the resene and resin acid portions of Manila elemi. Each of these was found to consist of a mixture of substances. Further investigations along these lines should be carried out.

SUMMARY

Manila elemi is a resin that is contained in the bark of the pili tree, *Canarium luzonicum* (Blume) A. Gray. This tree grows abundantly in low and medium altitudes in the primary forests of Luzon, Mindoro, Ticao and Masbate.

When the bark of the pili tree is cut the resin oozes out. At first it is always soft and has a very fragrant odor. On standing, however, it gradually loses volatile constituents and hardens. The resin is said to flow best during the rainy season and accumulates in large masses of more than 30 kilos. It is used in making plasters, ointments, paints, varnishes, and for various other purposes.

An accurate and convenient method was devised for analyzing Manila elemi. This resin was found to consist principally of resenes together with some resin acids and volatile terpenes. By steam distilling the resin the volatile terpene oil passes over into the distillate leaving a residue of resenes and other elemi constituents. These various groups of residual substances are separated from each other by appropriate procedures.

The resenes are not acted upon by alkalies and other common chemical reagents. This characteristic is said to enhance the value of resene resins for the manufacture of varnishes.

Using a different method of analysis M. Mladenovic obtained results similar to those recorded in this report.

BOOKS

Books reviewed here were received by The Philippine Journal of Science from their respective publishers.

REVIEWS

Surface Active Reagent; Theoretical Aspects and Applications. By C. B. Young and K. W. Coons. Brooklyn, Chemical Publishing Co., Inc., 1945. 381 pp. illus. Price, $6.00.

Information obtained from this book will prove of great value to chemists and other technical men of industries. This book contains numerous tabulated data and illustrations, and a list of selected references at the end of each chapter.

The first part of the book deals in detail with the theoretical side of surface tensions, the relation between surface tension and other chemical and physical properties of matter and the structures and effects of surface active agents. Methods of determining surface tension are given. The apparatus used are described. Chemical and mathematical equations and a comprehensive table of such data as the trade names of the wetting agents, type or chemical compositions of the compounds and their use in industry and manufacture are also available.

The second part discusses extensively the utilization of the phenomenon of surface tension in various branches of industries. Many specific formulas for emulsions and other products based on the applications of surface tension agents are given at the end of each chapter.—C. N. C.

Fundamental Electronics and Vacuum Tubes.—By Arthur Lemuel Albert. New York, The Macmillan Co., 1947. 510 pp., illus. Price, $6.00.

This book is devoted to a study of the fundamental principles governing the operation of electronic vacuum tubes and associated devices with the aim in view of imparting to the technical student a thorough knowledge of the great possibilities which the vacuum tube may be put into use in the ever expanding field of electronics.

The first chapter deals with the elementary concepts of matter, waves, electron, proton, positron, neutron, atomic structure, photon, quantum-treated in accordance with the latest theories and in a precise and clear style. This is followed in the next two chapters by the various processes of electron emission, the third chapter being devoted entirely to thermionic emission which is the most common type of electron emission used in commercial electronic today. The succeeding

five chapters treat of the electrical characteristic of practically all types of vacuum tubes, from diodes to multi, electrode vacuum, both gaseous and high vacuum types. The treatment is mathematical and includes a considerable number of characteristic curves and diagrams which may be of practical value to the technical researcher. The last seven chapters are devoted to the applications of electronic vacuum tubes apparently with especial reference to communication purposes—the use of vacuum tubes as voltage amplifiers, oscillators, including ultra high frequency oscillators, modulators, demodulators, etc. A discussion on the use of vacuum tubes as measuring devices, such as vacuum tube voltmeters, cathode ray tubes and photo-electric tubes, is also included.

References, questions and problems are provided at the end of each chapter, making the entire treatise a suitable textbook for any one who desires to have a thorough foundation in electronics.—E. P. R.

Dynamic Aspects of Biochemistry. By Ernest Baldwin. New York, The Macmillan Co., 1917. 456 pp., illus. Price, $4.00.

This book gives a good idea about enzymes, with their functions and properties well discussed. The role they play in the utilization of food substances by the animal and human body is well presented. The book gives a good discussion on the ability of simple organisms to utilize simple substances for their needs, deriving their energy from the energy locked in complex substances. It also shows the dependence of higher forms of animal life for their subsistence on higher forms of animal and plant.

Students on the fundamentals of fermentation should take note of this book for its well written accounts on carbohydrates, nitrogen, proteins, fats and the end products of metabolism. This book is an excellent text or reference for students in fermentation.—R. R. O.

Inorganic Process Industries. By Kenneth A. Kobe. New York, The Macmillan Co., 1948. 371 pp., illus. Price, $6.00.

The book is an able presentation of the processes involved in the operation of some inorganic chemical industries. The first chapter is devoted to technical literature on related subjects. It gives a practical approach to the first problem confronting a researcher or a technologist seeking information on matters pertaining to his field of activities. The other chapters give a thorough description of the manufacturing processes, the function of each equipment as a unit as well

as an integral part of the whole system and diagramatic illustrations of the steps involved in the processing of materials from their raw conditions to their final forms. From the accumulated information, so methodically presented and comprehensibly discussed, the researcher or professional man is placed in a position to understand thoroughly the conditions under which the different units of a system operate to attain the desired results at a minimum expense.

The theoretical aspects of each process is also ably discussed, with a classified list of the references wherefrom detailed technological information on the various phases of the manufacturing operations may be secured.

The economic side has not been neglected. The relative costs of production by different processes and the marketing problems relative to trade names, commercial gradings, method of shipping, etc. of products are thoroughly discussed in the most practical way.

The book as a whole is a valuable guide for technical men engaged in teaching, research, factory control or consulting activities and for students of industrial technology. It should form an integral part of their reference libraries.—R. H. A.

Zinsser's Textbook of Bacteriology. Revised by David T. Smith and others. 9th ed. New York, Appleton-Century-Crofts, Inc., 1948. 992 pp., illus. Price, $10.00.

Zinsser's Textbook of Bacteriology is already known and has been used by medical students since its first publication in 1910. The 9th edition, 1948, of the book which was revised and edited by the students of the author gives in detail the modern conception of the biological characteristic of the organisms and the reactions of the living tissues to the bacteria and their products.

The book is divided into seventy-seven chapters. The outline and arrangement of the chapters remain the same as in the eighth edition with the exception of the chapter dealing with Pleuro-pneumoniae-like organisms and the Testing in vitro of sulfonamides and antibiotics (penicillin and streptomycin) sensitivity which are new additions. The nomenclature is based on Bergey's Manual of Determinative Bacteriology, 6th edition, 1948. (For example in chapter XXXIII *Salmonella typhosa* and Typhoid fever, the causative bacillus of the typhoid fever, had many names: *Bacillus typhosus, Bacillus typhi abdominalis, Salmonella typhi, Eberthella typhosa* and finally *Salmonella typhosa.*)

Quite a long list of antibiotics is presented with their agent, source, range of activity, toxicity, properties and uses.

The definition of every subject is simple and sufficiently comprehensive, and every discussion is clear and accurate based on up to date findings of known researchers. The book contains every phase of bacteriology, from bacteria, moulds fungi, filterable viruses, their environment, metabolites, modes of infection and control to immunology, antibodies and compliment fixation. In the discussion of the normal blood typing it also shows the importance of the detection of the Rh factor, which is important because of its immunizing ability.

Extensive work on filterable viruses has been recorded and supported with electron micrographs. The medical mycology is fairly discussed with many recent illustrations of the causative organisms. Due to the clear and accurate presentation of facts and the inclusive and thorough coverage of everything regarding bacteria known to date, the Zinsser's Textbook of Bacteriology is highly recommended for medical students, medical practitioners and health officers not only for their study but also as a guide for extensive work. The book is also valuable for the extensive references cited in it.—M. B.

A Textbook of Heat for Upperclassmen. By LeRoy D. Weld. New York, The Macmillan Co., 1948. 436 pp., illus. Price, $5.00.

A glance on the table of contents will show that the subject matter treated is adequately covered. The outstanding feature of the book is its plain and simple treatment of well-known theorems and laws; this style is well shown in Chapter I when the author made use of Longfellow's character in "Song of Hiawatha" Pak-Puk-Keewis "who can pass readily from one another of a great variety of forms" to avoid confusion in the often use of expressions as *transfer of heat, heat of vaporization,* etc. And though he intended this textbooks for upperclassmen familiar with differential and integral calculus, he proceeded to show step by step the derivation of every formula—thus keeping the treatment well within the comprehension of the usual run of students. For those who want to delve deeper in the subject, a list of references is appended to each chapter. In short, here is your "Textbook of Heat" in eleven easy chapters.—L. G. A.

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CONTENTS

	Page
COPELAND, EDWIN B. A. D. E. Elmer: Leaflets of Philippine Botany	1
COPELAND, EDWIN B. Pteridaceae of New Guinea	5
BAISAS, F. E., and ADELA U. PAGAYON. Notes on Philippine mosquitoes. XV. The chætotaxy of the pupæ and larvæ of Tripteroides	43
PARAS, ERNESTO M. Blood-chemistry studies in leprosy. III. Total calcium, diffusible and non-diffusible, calcium, albumin and globulin	73
HAMM, WM. S., and ARTHUR AVERY. Philippine solar salt industry	85
ESTAMPADOR, EULOGIO P. Studies on Scylla (Crustacea: Portunidae). I. Revision of the genus	95
MANALO, GLORIA D., and AGUSTUS P. WEST. Analysis and composition of Manila elemi	111
BOOKS	121

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